1982 ANNUAL REPORT

ELECTRIC POWER RESEARCH INSTITUTE

Ten years of research and development by the nation's electric utility industry

EPRI JOURNAL

Volume 8, Number 3
April 1983

EPRI JOURNAL is published monthly, with the exception of combined issues in January/February and July/August, by the Electric Power Research Institute. The April issue is the EPRI *Annual Report*.

STATEMENT OF BUSINESS

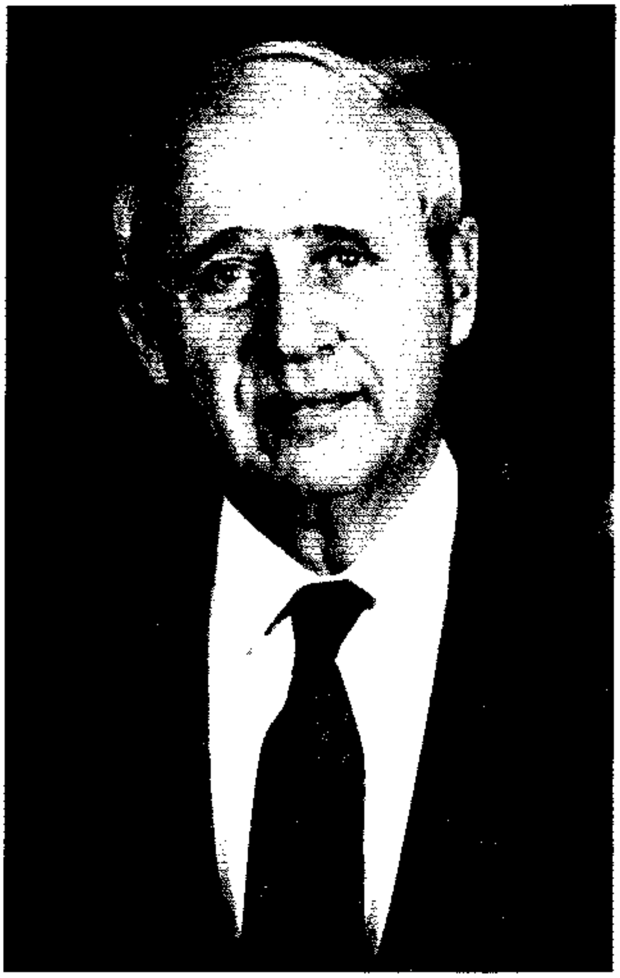
The Electric Power Research Institute (EPRI) plans and manages research and development on behalf of the nation's electric utility industry and the public. The Institute's objective is to advance capabilities in electric power generation, delivery, and use, with special regard for safety, efficiency, reliability, economy, and environmental considerations.

EPRI was founded in 1972 as a nonprofit corporation to provide professional planning and management of an industrywide research and development program. Financial support of the Institute and its programs is furnished by public and private member utilities in proportion to their electricity sales. Together, EPRI's members produce about 70% of the electricity supplied by U.S. utilities; their aggregate 1982 payments to EPRI were slightly below $280 million.

Two special advisory groups complement EPRI's Board of Directors in furnishing policy and program guidance. The Research Advisory Committee, made up of utility executives, provides technical counsel on EPRI's programs and progress. The Advisory Council, drawn from the spheres of education, business, government, science, and other groups outside the utility industry, advises EPRI's Board and president on the emphasis and direction the Institute's research program should take in meeting the broad needs of society.

Research and development authorized to date has a total estimated cost of about $3.5 billion, of which about 63% will be paid by EPRI and 37% by cosponsoring organizations. ■

Cover: The bipolar plate of a phosphoric acid fuel cell controls the flow of fuel and oxidant within the cell.



True historic value is difficult to recognize in a period as short and as recent as the 10 years just past. This is especially true when one has been very close to an enterprise. Even so, a few impressions from my association with EPRI are important as electric utilities consider their individual roles in the industry's technologic development.

R&D by and for electric utilities was a threatened practice when EPRI was organized. This was in 1972 and I was chief technical officer for Jack Horton of Southern California Edison Co., a member of EPRI's first Board of Directors. Individual utility and manufacturer research programs were not highly coordinated or visible, nor were various regional and ad hoc joint efforts. Most significant, neither was looked upon as aggressive or innovative. The industry was growing at a great rate, but its long tradition of ever-lower electricity cost was clearly ending. These circumstances had motivated legislative proposals for nationwide electric rate taxation and a federal agency to plan and manage the industry's R&D.

EPRI was the response to that challenge, unique in its form and capability. Notably, it is not a captive of any segment of the industry. Because utility markets are defined through regulation, EPRI is funded and staffed from all industry segments, and it is thus a forum of technical cooperation that would not be permitted among traditionally competitive producers.

Since 1972 there has been profound change in the nationwide growth rate for electricity demand, from an average of about 7% annually to an average of less than 3% and an actual decline in 1982. Ten years ago, only a heretic would look favorably at 4% growth; today most utilities would prefer it were even lower—unless there were marked reductions in the cost of nearly everything needed to do business.

Technology expectations have also changed tremendously for the industry (and for EPRI, accordingly) in the planning and management of R&D. Ten years ago we foresaw widespread escalation of transmission line voltages. Today that trend is reversed. In fact, one practical alternative is generation with smaller units connected directly into the lower-voltage grid.

In 1972 we were looking at great numbers of quite large nuclear power plants, a technology well established in the preceding 10–15 years. Today, at least for the moment, nuclear power has lost its glitter as a business option; few utilities can or have the need to make the required investments of time and capital.

Concurrent with these changes are greatly increased emphases on control of fossil fuel power plant emissions—gaseous, liquid, and solid—and on extended, reliable service lives for all types of existing power facilities.

In this context of markedly altered economic capability and technical requirements, EPRI has furnished R&D results in a remarkably rapid manner. It is a genuine and welcome surprise that EPRI so quickly became a producing institution. Despite the industry's slowed growth and accelerated costs, the overall research investment is up for the decade, even after accounting for inflation.

It is sometimes argued that these gains are illusory because utility industry manufacturers are doing less research. To the extent that this is true, it is for a good reason that only serves to reinforce the value of EPRI's presence. Manufacturers must have an order backlog to support research with any continuity, but especially among producers of turbine generators, heavy transformers, and other large apparatus, there is not that backlog today. In its absence, the aggregation of available funds in EPRI has enabled R&D to continue at a level that no single manufacturer (or utility, for that matter) could consider, even in the best of economic times.

As a forum for technical cooperation, EPRI not only has fostered R&D that otherwise would be infeasible but also has encouraged new ways of thinking about technology applications and their consequences for various utility constituencies—ratepayers, taxpayers, shareholders, and members. Dogmatic positions on technology matters have been aired, reconsidered, and revised in the interactions of EPRI staff and their utility advisers, and this new, open attitude has, I think, spread beneficially throughout utility management thinking. EPRI itself has scrupulously stayed out of the utility management business, so this openness was not planned or even foreseen in EPRI's mission. Nevertheless, it is a timely and healthy result.

A deliberate example of the confluence in thinking about technology and its implications is the subject of conducting R&D in electricity end use, that is, on the customer's side of the meter. There is mixed opinion on this, evident in discussions among EPRI Board members, but we expect to find a consensus that will give EPRI management the policy guidance it needs for confidence in R&D planning.

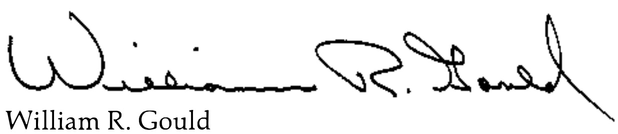
I view the need for electricity end-use research very positively, seeing it as part of an endeavor to make electricity a more efficient energy medium for everyone. This is a matter of attitude toward an R&D area, not of work priority or level of investment. As a pragmatic, commercial matter, end-use R&D is in the best tradition of marketing—helping customers make best use of a product or service—and it is a logical extension of the home economics and home energy conservation guidelines long offered by utilities.

The key concept here is cost-effectiveness. Familiar enough in the evaluation of individual utility plant equipment options, it is applicable in an expanded context that takes in the customer's costs as well. It is the policy of my company that no decision is reached without considering its impact on the customer. This is a matter of consciousness more than of set procedure. I believe such a view of cost-effectiveness is also appropriate and implicit in our industry's criteria for its R&D.

The viewpoints and forces that motivated our industry to establish EPRI still exist. If anything, the economic and regulatory challenges today are even stronger. Our industry is widely seen as monopolistic and treated accordingly. A more positive characterization is simply that we are asked, urgently and continually, to act responsibly, in the public trust. It behooves utilities to reply in that spirit; I believe we are doing so and that EPRI is the principal expression.

Our work is indeed cut out for us, but EPRI meticulously schedules only what is reasonable from year to year. Recently, in fact, inflation slowed, and the estimated cost of planned 1983 R&D fell accordingly. EPRI management therefore recommended and the Board agreed that the previously set 1983 member payment be reduced to yield the lower revenue EPRI needs for 1983 R&D activity.

It is vitally important that EPRI and the utilities continue their work together in this fashion, cooperatively pressing the frontiers of technology for improvements in cost-effective electric supply from its energy source to its point of application.



William R. Gould
Chairman

EPRI's 10th anniversary marks the end of the pioneering decade in which the electric power industry initiated large-scale, collective R&D. Since the beginning of operations in 1973 the Institute has benefited from the extraordinary support of its member utilities—both in funds and in the people who work with us through our extensive advisory organizations. These dedicated utility representatives bring a unique perspective to the research advisory committees. Together with our Board, they advise and help direct the Institute's R&D program and assist in communicating the results of this program to the technical community. In addition, our Advisory Council provides essential insights from a broad spectrum of public opinion. The importance of these remarkable advisory groups is second only to that of EPRI's able and experienced staff—the Institute's most valuable asset.

Several other groups have also contributed to the maturation of EPRI's R&D program. From our many contractors, who are truly our partners in research, we have received fair return in knowledge, skill, and working cooperation at every level of inquiry. We have worked productively on joint projects with many government and regulatory agencies, with a shared sense of public responsibility. Largely through the efforts of local utilities, public utility commissions have shown greater recognition of the importance of R&D to the future. We have also benefited from work in other countries on the generation, distribution, and use of electric power. EPRI now has 14 formal exchange agreements and many more informal contacts abroad.

Much of EPRI's success has been due to a close working relationship developed with the utility trade associations—EEI, APPA, and NRECA. They have guided the Institute through conception, birth, and adolescence with insight and keen political perception. We are very grateful to these and all the other groups and individuals that have done so much to help bring EPRI to its current level of maturity and productivity.

Our programs are now yielding substantial dividends useful to consumers, utilities, and the national economy. A 10th anniversary makes a good occasion for reflection and assessment, so let me list just some of what utilities have accomplished through their support of EPRI programs. Above all, they developed an organization that could help the industry cope with the major upheavals of the 1970s, including instability in the price and availability of oil, the rise of the environmental movement, and sharply accelerating regulatory requirements. They secured the means to improve the performance and lifetime of existing plants and electrical systems. And for the future, they have sponsored demonstrations of innovative technologies for safe and economical new power plants. These accomplishments are now taking on additional significance in light of declining federal support in many areas of R&D.

By being persistent in a period of great discontinuity and indecision, EPRI has grown to become a major technical resource for the electric power industry. With its internationally recognized staff, the Institute has been able to bring vital expertise to bear on some of the critical problems facing the industry. With equal vigor we have been able to work on long-term projects with participants from government and industry or to respond quickly to emergencies like the accident at Three Mile Island. We have helped to provide unique facilities for testing, training, and quality control, while developing information and analysis needed to protect the public through reasonable standards for nuclear safety and coal combustion.

In an era of recession and economic difficulty for the whole nation, EPRI has worked with utilities to realize the potential of electrification for revitalizing American industry and reducing the consumer's energy costs. I am optimistic, both about the gradual recovery of America's competitive position in world markets and about the steady growth of demand for electric power. Nevertheless, both EPRI and the utilities must adjust their expenditures to the constraints of the present and accommodate uncertainties in their planning for the future.

EPRI's strategy is to concentrate R&D on the most pressing needs of the industry, while still pursuing the new technologies that will be required to meet the demands of a brighter future. Accordingly, our near-term focus is on programs that will help utilities reduce costs, meet regulatory requirements, and increase the availability and lifetime of present facilities. In cooperation with individual utilities, we are developing new ways to conserve energy and make the end use of electricity more economical. To delay requirements for installing new power generation capacity, we are working on several promising techniques of load control, energy storage, and cogeneration.

For the midterm, we are concentrating on several major demonstration projects. These promise to provide utilities with new generating options that will be both clean and economically competitive. In addition, some of them promise to be small and modular, which will give them the potential for more rapid construction and placement in urban areas.

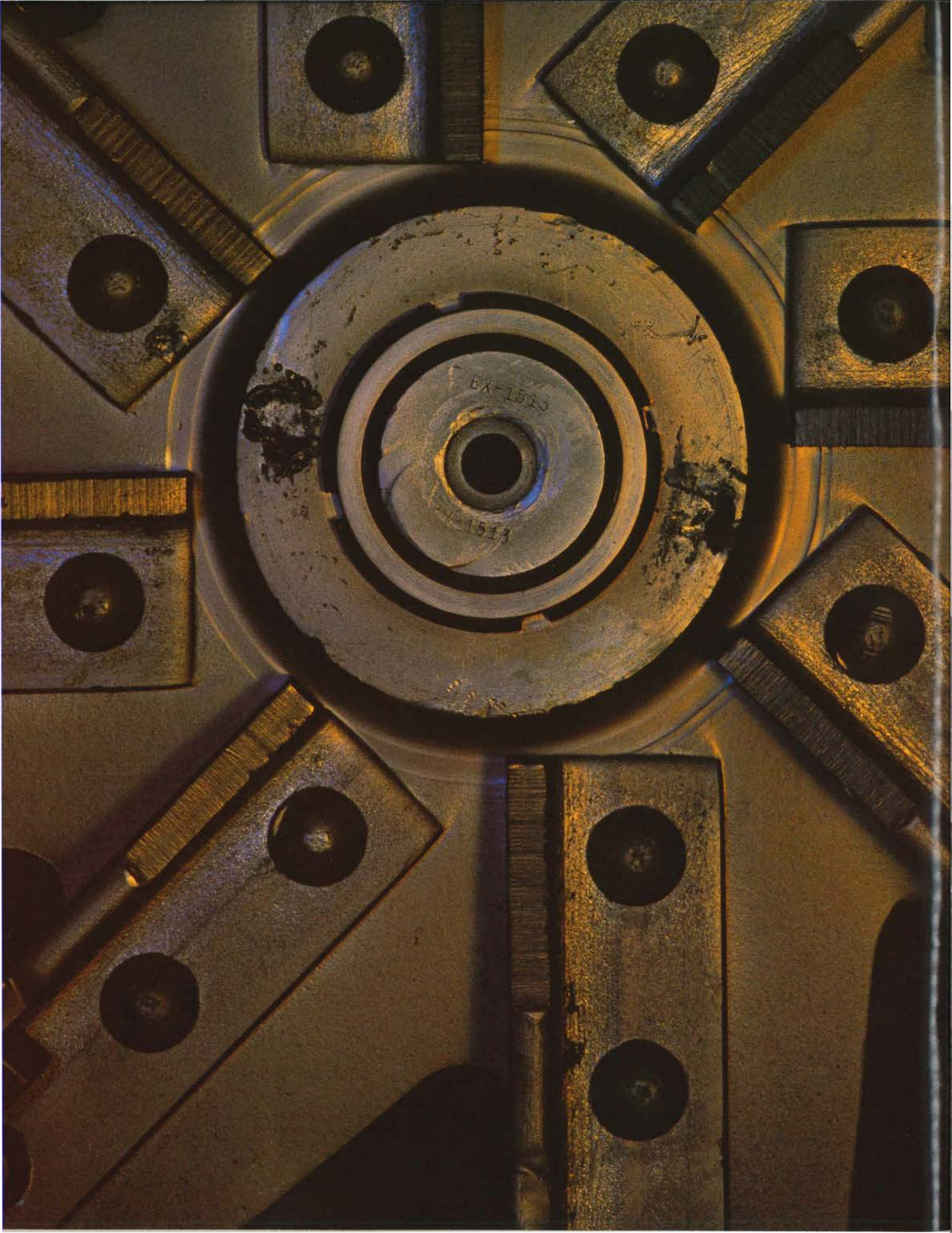
For the long term, we are looking at technologies that will improve our ability to use America's vast coal resources, to sustain nuclear power, and to introduce renewable resources as they become economically feasible. We are beginning to work with large industrial users of electricity to explore more-efficient production processes. And we are expanding our exploratory research in the domains of science and engineering that are most likely to become the sources of major new energy systems.

As the federal government reduces its support for near- and midterm R&D, EPRI's work in demonstrating new technology for utilities will become even more important. Much of this work will be done through cooperative projects, either cofunded with the government or developed entirely within the private sector by partners from various industries. In either case, EPRI will likely play an increasingly active role as a catalyst in the formation of these cooperative projects.

The government and private concerns are increasingly seeking out individuals from EPRI to act as advisers and consultants. But the expertise developed within EPRI over 10 years of work should also be used to assist individual utilities in solving their immediate problems. We need the counsel and guidance of our utility members to help the Institute adapt to its new roles and to communicate the results of our research more efficiently to all who need them.

From a view of EPRI's past and present achievements, I am optimistic about the future. As has happened during each period of change in the Institute's history, we will use ingenuity and knowledge to adjust old patterns and introduce new ideas. In this way, we can work effectively with other concerned members of the utility industry to preserve an electric power system that is the standard for the world, while helping other industries to restore America's overall competitive position.

Floyd L. Culler
President


EX-1513

RESEARCH AND DEVELOPMENT

An overview of R&D priorities and programs from the perspective of EPRI's vice president for research and development and from the directors of EPRI's six technical divisions:

- □ Advanced Power Systems Division
- □ Coal Combustion Systems Division
- □ Electrical Systems Division
- □ Energy Analysis and Environment Division
- ☑ Energy Management and Utilization Division
- □ Nuclear Power Division

Richard E. Balzhiser, Vice President
Research and Development Group

During the first 10 years of its existence, EPRI continually adjusted its research program to meet the changing needs of the member utilities. Striking an appropriate balance between near-term and long-term projects has been a critical part of that process. As the Institute enters its second decade, its outlook will continue to be dominated by the uncertainty that developed after the oil embargo and still makes utility planning so difficult. Working closely with the industry's advisory structure, we are continually evaluating the focus of EPRI's research program to provide utilities with the resilience and flexibility they need to adapt to the uncertainties of the 1980s and beyond.

In large measure the Institute was formed because of industry concern over how to meet rapidly growing demand and keep costs down while devoting more resources to environmental protection. Such goals clearly required a major research commitment, much of it devoted toward intermediate and long-term programs to complement near-term efforts of the industry and its suppliers. However, as growth rates began to slow and as working capital became more difficult to obtain, emphasis necessarily shifted toward short-term research focused on extending the life and productivity of existing investments.

This effort has been largely successful, as the commercially viable technologies now emerging from EPRI's research efforts can attest. Member utilities throughout the country are beginning to reap the rewards of their R&D investment through new products and techniques that can help cut costs, save energy, increase operating flexibility, and conserve scarce capital. To be able to continue building on these achievements, however, we must continue to look toward longer-term goals and maintain an appropriate balance in program funding that reflects dramatic reductions in federal spending on energy R&D.

In looking ahead, several pressing needs of utilities will have to be considered in setting research priorities. Among the most important is the requirement to conserve scarce capital by extending the life of existing coal-fired plants. Research emphasizing plant reliability, environmental control, fuel quality, and plant performance is becoming increasingly important to most utilities. This research now includes major commitments to the Emissions Control and Test Facility and the Coal Cleaning Test Facility, in addition to extensive work on those plant components responsible for most forced outages.

Our research efforts must also reflect the sizable investment the industry is making in nuclear power and its growing importance in the generation mix. This work focuses on generic safety and licensing issues and generic reliability issues, which are not uncommon in a relatively new technology like the nuclear steam supply system. It is equally important that the viability of nuclear power be maintained because of growing concerns over acidic deposition and carbon dioxide buildup in the atmosphere, which are associated with the long-term use of fossil fuels.

Even at slower demand growth rates, over the coming decade utilities will face the need to increase transmission of electric power over longer and tougher distances. They will also face some important changes in load characteristics. EPRI's aim in this area is to minimize the cost of transition by helping utilities achieve more effective system operation and extend the reliability and availability of existing equipment. Such work will include development of more efficient and reliable components for transmission and distribution systems, improved maintenance equipment and practices, and cost-effective means to remotely control and meter end use of electricity.

As economic uncertainties increase and as environmental issues become even more complex, EPRI will have to work still more closely with utilities to anticipate challenges, rather than simply react to them. Several tangible results of past efforts in this direction are now available in the form of improved information and decision-making tools that utilities can use in their strategic planning. A new program has been formed to help integrate these research results and transfer them to potential clients. Also, added emphasis will be placed on studying acidic deposition, long-range transport of emissions, solid-waste disposal, and the effects of power generation on water use and discharge.

Several advanced power systems are now approaching the critical demonstration phase of development. Because many of these large projects have been severely affected by changes in government funding, EPRI has been faced with difficult priority decisions for future work. Major funding has been committed to the 100-MW (e) gasification–combined-cycle plant at the Southern California Edison Co. Cool Water station. A successful development program for fluidized-bed combustion has led to the operation of a 20-MW pilot facility at TVA's Shawnee station. And a 100–200-MW demonstration of this technology at a utility site is now planned for the mid 1980s.

Because of electricity's versatility, it will have a critical role to play in helping to increase the productivity of American industry. EPRI's goal is to help maintain and enhance electricity's competitiveness in the energy marketplace. This can be done by helping to accelerate the electrification of industry and to provide the type of load growth that permits utilities to make the most effective use of their plant investment. Such an effort will require closer cooperation with industries that can benefit from such emerging technologies as microwave heating and drying, industrial heat pumps, laser applications, induction heating, plasma processing, robotics, and electronics. Similar efforts, focused on residential and commercial users, can improve heating and cooling loads and so help utilities reduce sharp seasonal peaks of demand.

EPRI research cannot be expected to eliminate much of the uncertainty that comes with rapid changes in our society, but EPRI does expect to contribute to the utility industry's ability to cope. By conducting load research, EPRI can help utilities benefit from information gained at considerable expense on other systems. Research on the price elasticity of electricity can help utilities anticipate customer response sufficiently in advance to take appropriate action. New modular generation options, with short lead times and minimal field construction, should permit utilities to delay commitments to new plants—especially where load growth uncertainty is high and where the cost of construction work in progress is not allowed in the rate base. Examples of such technologies include fuel cells, pressurized fluidized beds, and gasification–combined-cycle plants—all having the ability to use coal or synthetic fuels derived from coal with minimal emissions and water consumption.

Through such efforts, EPRI can help the capital-intensive utility industry face present financial uncertainties, while continuing to make the difficult transition away from fluid fuels toward greater use of coal, uranium, and renewable resources. ■

Dwain F. Spencer, Director
Advanced Power Systems Division

New Fuels and Energy Options

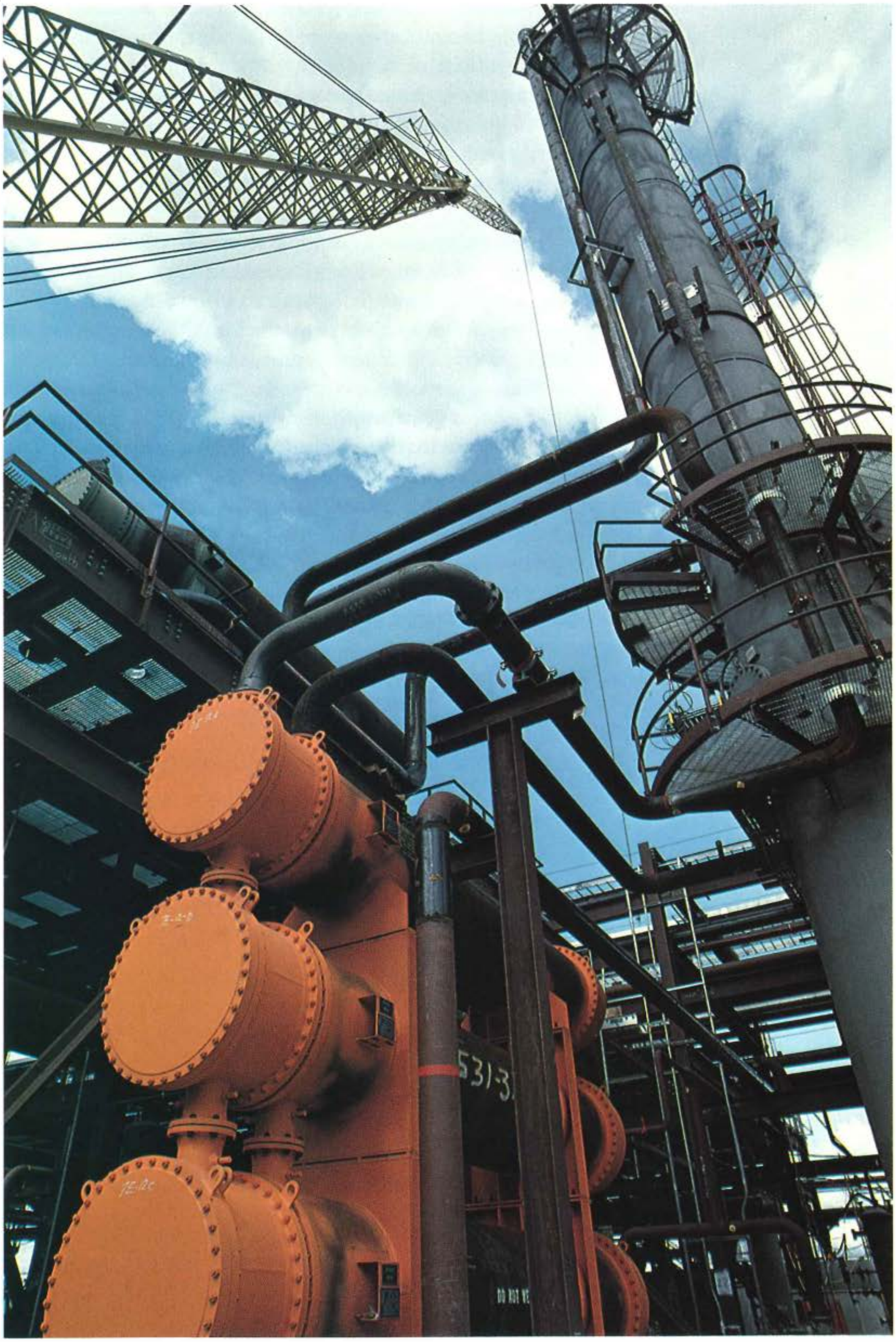
Utility requirements for new power generation options have evolved since the Advanced Power Systems Division's first R&D programs were organized 10 years ago. The primary need then was for intermediate-duty (cycling) units that would be reliable and economic at a capacity factor of 35–40% or technologies that could replace oil- or coal-fired units. Conventional combined-cycle plants using combustion turbines and steam turbines were seen as a likely prospect, if they could be designed, built, and operated with higher reliability. Solar, wind, and geothermal energy were seen to have only limited geographic potential for utility use, and not until the mid to late 1990s.

The 1973 oil embargo and its aftermath reshaped matters. Petroleum prices were shocking, but long-term availability was an even more serious concern. Alternative domestic fuel and energy resources were suddenly the order of the day. Coal conversion processes—the whole area of synthetic fuels—became an urgent agenda because they could produce essentially direct substitutes for oil and natural gas. Renewable energy R&D took on substance that was more than cosmetic, more than just an assessment of the impacts that utilities could expect from the variety of solar and wind energy systems that were suddenly popular.

Research soon confirmed that the new fuel and energy options could be channeled into utility systems but that many were not directly interchangeable with each other or with existing power units. Solar-thermal and solar-photovoltaic energy conversion processes, for example, are interruptible and would need energy storage for reliability. Synthetic fuel processes produce a wide range of product mixes, or slates, of liquids with different compositions and boiling points or gases with different Btu contents. Further, the more we learned about advanced power options, the more expensive we found most of them to be.

Because new fuel and power plant characteristics are so clearly interdependent, the division began to focus more sharply on the need for system efficiency and economy all the way from resource (whether coal, solar, or any other) to busbar. In coal gasification, this meant functional integration of synfuel production and power generation processes into one system. In coal liquefaction, it meant assurance of acceptable fuel handling and combustion characteristics, as well as better power generation efficiency to offset the high synfuel cost.

Consistent with the division's primary original goal of cycling power options, the highest-priority projects came to be coal liquids production and solar-thermal energy conversion. In this connection, two major R&D tasks of the decade were completed in 1982 when a pair of 250-t/d coal liquefaction pilot plants finished their planned operations, producing satisfactory "crude oil" from a number of feed coals. These fuels are now being tested in boilers, combustion turbines, and diesel engines as substitutes for petroleum products and natural gas.



Heat exchangers and process column under construction at the Cool Water gasification–combined-cycle power plant.

Hundreds of mirrors can be positioned to focus the sun's heat on a central steam boiler in this demonstration of solar-thermal electricity generation.

Since about 1978, industry requirements for advanced power systems have changed, calling for an important shift in the division's primary goal. Economic, environmental, and institutional problems have slowed electricity demand growth and added significantly to the costs and construction times of coal and nuclear power plants. Because of this, and because the future growth rate is uncertain, utilities need baseload plants that can be built quickly in economical capacity increments and operated cost-effectively over a wide output range.

As these criteria for new baseload power technologies became apparent, coal gasification R&D intensified, especially for those processes that could be integrated with combined-cycle power units. Steady-state operation had been the rule for such processes, suggesting that integrated gasification–combined-cycle plants could be a useful new baseload option. However, the late 1970s also saw the advent of an IGCC system capable of following utility load changes, a welcome technical surprise that opened up its range of application.

Simultaneously, the quest for reliability in IGCC systems—that is, assured availability in operation—led to designs with redundant modular units, each with relatively small capacity. This modular approach was adopted from the aerospace and petrochemical industries, where parallel trains of subsystems or process units are used for reliability and for tailoring capacity.

Process integration and modularity, therefore, have also become goals of our advanced systems R&D. Along with cycling capability, they are the principal means of achieving capital and operating economy, reliability, and flexibility.

As EPRI's work began, and especially as the energy crisis developed, it became apparent that advanced energy options had to be encouraged, but that they could be oversold. This is particularly so with renewable energy technologies. There is no precedent for their use in bulk electricity generation; and utility criteria for energy quality, reliability, and economy are rigorous. In some assessments we have therefore been seen as the devil's advocate, whereas our goal was and is simply to pursue an R&D course that is thorough on behalf of utilities and their special needs.

A preamble to hard technology research, in our practice, is an engineering and economic evaluation—that is, the fullest possible advance determination of the requirements the system must meet and the impacts that will arise from its use. This management approach, also adopted from the aerospace industry, places EPRI in a pivotal technical position with utility, vendor, government, and other participants in the R&D process.

Because of the risks and costs of today's power technology development, the follow-on step of full-scale demonstration has become a key program focus. The past year reveals important examples. One was the groundbreaking for a 50-MW binary-cycle plant to demonstrate geothermal energy conversion from hydrothermal resources. Another was successful operation of a geothermal wellhead generating unit that uses a rotary separator to extract both hydraulic and thermal energy from the geothermal fluid. A third example is the 100-MW Cool Water IGCC plant under construction throughout 1982 and 1983, with startup planned for 1984.

Even beyond the demonstration stage, the Advanced Power Systems Division is being sought out by utilities for engineering support in maximizing the value of new fuels, controls, and systems in such applications as cogeneration and repowering. With the advent of very promising gasification and geothermal technologies, the division has encouraged the formation of groups of prospective utility users to aid development and to exchange information.

As results emerge from EPRI's work, it is apparent that the utility industry is being accorded credibility for its readiness and ability to recognize and solve problems. For advanced power options, with many concepts totally new to the utility industry, those solutions are complete only when their performance and reliability are proved in operation. Technology demonstration, therefore, continues to be a key part of our division's R&D effort and should give utilities confidence to adopt at least some modular power systems in the 1990s. ■

Wind turbines are being proved today in sizes up to 2.5 MW. Clusters of such machines can produce supplemental electricity without fuel cost.

Newly developed equipment at a Utah geothermal well captures both thermal and kinetic energy with a combination of steam and hydraulic turbines.

First in the laboratory, then in pilot and demonstration plants, coal liquids are being developed as clean, efficient substitutes for oil fuels.

Kurt E. Yeager, Director
Coal Combustion Systems Division

Adapting Coal to a New Age

Principal challenges facing the Coal Combustion Systems Division today mirror those that the utility industry will likely be pursuing for the rest of the century: to get more out of existing generating capacity and to minimize the cost of any new capacity additions. The imperative of meeting these challenges results from a number of new constraints that are reshaping the technical approach of the U.S. utility industry's use of coal. In the past decade these constraints—financial, environmental, and technologic—have placed an increasing premium on near-term, low-risk technologic innovation.

Among the coal-based technologies, efforts to improve the reliability and longevity of existing conventional pulverized-coal plants clearly qualify in this regard. But the development and application of fluidized-bed combustion—a technology with great potential and on the verge of commercial demonstration—applies as well.

Over half of the electricity generated in the United States today is produced by conventional pulverized-coal-fired plants. Yet there are many opportunities for improving the performance of these plants. New practices, procedures, and hardware for better performance are now being put in place, and the notion that efficiency and reliability are in fundamental conflict is rapidly losing credibility. (This misconception for years has impeded the acceptance of performance improvements in coal plants.)

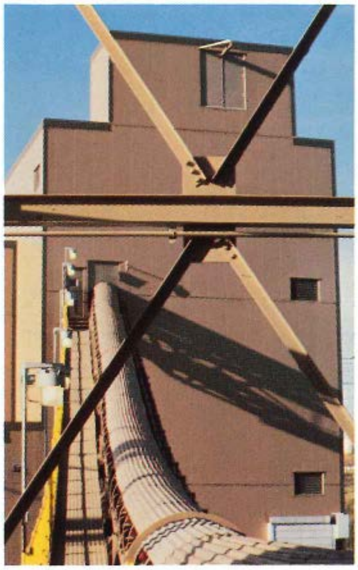
Within the CCS division, emphasis on plant performance improvements has been on reversing the persistent downward trends in average plant reliability and efficiency. These trends, characteristic of the 1970s, can be traced to a number of factors: reduced design margins as a result of financial constraints, rapid changes in the size and operating factors of new plants, restrictive environmental controls, and reduced quality of the coal, partially driven by the switch to low-sulfur, low-Btu coal for environmental reasons.

The division evolved as a separate entity within EPRI in the mid 1970s to address utility needs in meeting more-stringent environmental control regulations and in mitigating the impact of control equipment on overall plant reliability and efficiency. At that time, environmental control equipment was applied piecemeal, and because of often-inadequate pilot-scale development, these additions had a debilitating effect on plant operations for many utilities. The division's initial investigations were aimed at improving the performance of electrostatic precipitators to control particulate matter, but the work soon expanded into other areas of emissions control. To integrate research in this area, in 1976 the division began construction of the Emissions Control and Test Facility at the Arapahoe station of the Public Service Co. of Colorado near Denver.

Today there are eight individual pilot plants operating at Arapahoe. Investigations focus not only on control of particulate matter but also on control of gaseous emissions, water, and thermal

View from the bottom of a coal-fired boiler.

discharges. Work is also under way to assess and demonstrate a new concept called integrated environmental control. This concept formally recognizes the need for environmental control systems to be regarded as integral parts of a power plant rather than as add-on devices. The research focus is to determine which control devices work best with other devices and with the remainder of the power plant in a typical utility setting.



Conveyors at EPRI's Coal Cleaning Test Facility transport coal through alternative process and equipment sequences for removing mineral impurities.

Coal quality also emerged as an important area of investigation for the division in the 1970s—at first, with specific regard to its impact on environmental control equipment. This work is now centered in the division's Coal Cleaning Test Facility (CCTF) at the Homer City power station of Pennsylvania Electric Co. and New York State Electric & Gas Corp. The research scope has expanded to include assessment and characterization of the effect of coal quality on the reliability and efficiency of the plant boiler and auxiliaries.

A coal quality measurement technique called CONAC (continuous on-line nuclear analysis of coal) is being studied, complementing the CCTF work. Applications of CONAC include determining coal quality at the mine, coal blending, control of coal washing and beneficiation, prediction and avoidance of slagging and fouling, real-time heat rate determination, optimal load dispatch, and compliance with flue gas emission limits.

Another key to improving the efficiency, reliability, and longevity of existing conventional coal plants involves the ability of utilities to accurately monitor plant performance. Diagnostic monitoring systems allow utilities to anticipate problems by sensing performance abnormalities at an early stage. They are of particular importance today because many coal-fired units are approaching the limit of design life but must continue to function for many more years.

Fabric filter research is carried out at one of the seven independent pilot plants at the Arapahoe Emissions Control and Test Facility.

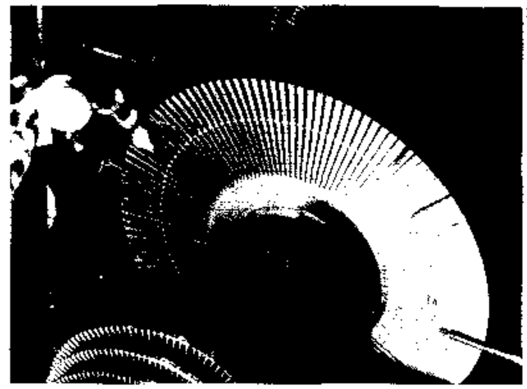
Diagnostic monitoring capability has been advanced in all areas of the power plant—boilers, turbines, generators, fans, pumps, and heat exchangers. In many cases, the needed monitoring systems are now commercially available. The reproducibility and accuracy of the diagnosis is a prime consideration with these monitors and is a focus of new division R&D efforts to install state-of-the-art monitoring systems at several host utility plants.

With respect to advanced coal combustion concepts, the division has been working to accelerate development and application of fluidized-bed technology since 1974. Fluidized-bed combustion, as an evolutionary improvement in direct coal combustion technology, is stirring considerable interest because of its distinct advantages over conventional pulverized-coal plants: reduced sensitivity to fuel quality, lower cost sensitivity to unit size, and an environmental control capability that is inherently more economical. In addition, improvements originally developed for conventional plants in materials and steam conditions can be applied to fluidized-bed systems for further efficiency gains and cost savings.

A cost-effective utility-scale design for atmospheric fluidized-bed combustion has been developed, and important hardware questions are now being resolved. To this end, the Tennessee Valley Authority has installed a 20-MW (e) engineering prototype fluidized bed at the Shawnee power station near Paducah, Kentucky. Operation began in May of 1982 with EPRI cosponsorship, and tests are scheduled to continue through 1986. The experience gained will provide the basis for 100–200-MW commercial utility demonstrations expected to be in operation in this decade.

Pressurized fluidized-bed combustion is an attractive technologic progression beyond atmospheric fluidized-bed combustion and can be an important future option for utilities. Plants of this advanced type using shop-fabricated turbocharged boilers in small, modular sizes can give utilities the ability to add capacity quickly and in small increments (100–300-MW units versus 600–1000-MW). In this approach, major reductions can be realized in the cost of work in progress, and a greater portion of existing turbine capacity now limited by steam supply can be recovered.

Regarding the division's proposed research program for the 1980s, a concerted effort will be made to more readily apply the results of R&D by involving the division's unique staff resources directly with individual utilities. Key goals in this effort are to become more service-oriented, to directly communicate the integrated results of research to utilities, and to work more closely with utilities in a support role as specialized technical staff. Beyond this, the division has an important role to play in helping domestic utility supplier industries remain technologically competitive. The goal is to ensure a secure supply of state-of-the-art hardware and technology for U.S. utilities now and in the future. ■



Research to extend the reliable life of turbines and other power machinery is a major avenue toward holding down future capital and operating costs.

Pilot tests in this 20-MW fluidized-bed boiler are building the data base for a cleaner mode of coal combustion.

John J. Dougherty, Director
Electrical Systems Division

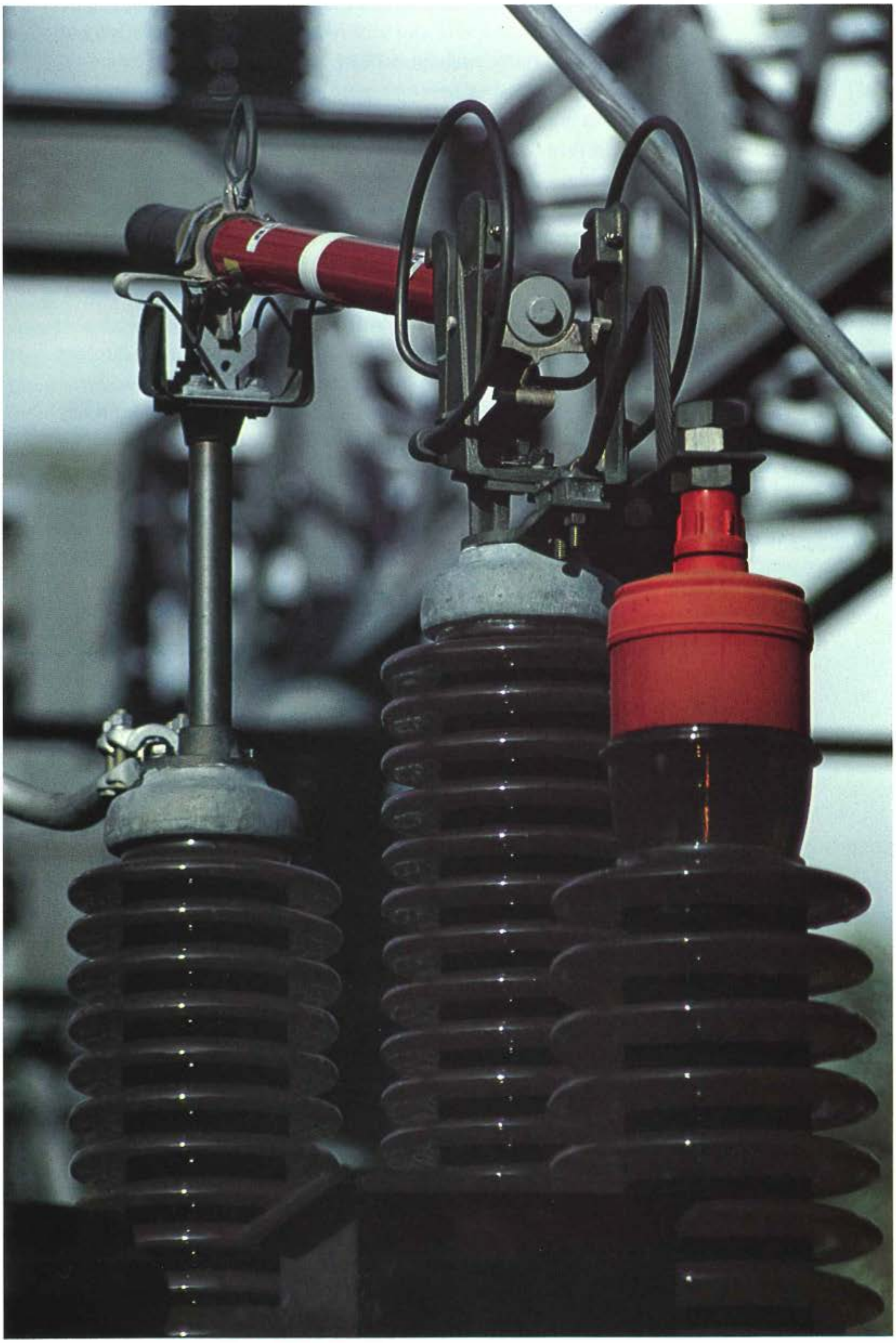
Higher Efficiency for Transmission and Distribution

Better ways of bringing electricity to utility customers have been the goal of EPRI's Electrical Systems Division from the start. Today, the goal remains the same, but the emphasis has changed. In the beginning the division was actively pursuing ways of bringing increasingly larger amounts of electricity to customers who used more and more each year. To meet this seemingly inexhaustible growth in electricity demand, utilities needed higher-voltage transmission systems, larger generators, larger transformers, and other hardware to deliver the product.

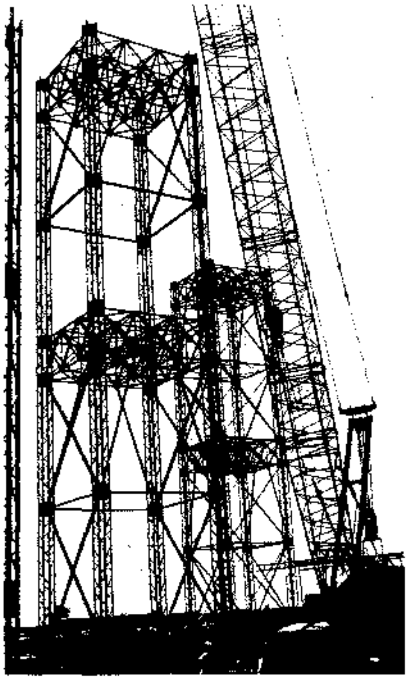
But after the 1973 oil embargo the industry's steady load growth began to subside at the same time as industry construction, operation, and maintenance costs began an unremitting climb. Priorities had to change, and the division's research had to follow. No longer are utilities anticipating the construction of larger and larger transmission and distribution systems to meet ever-expanding demand. Instead, they have to improve existing systems so electricity can be delivered more efficiently and economically than ever. The emphasis is no longer on bigger systems but on more efficient systems.

This shift in emphasis is bringing about continuing change in the ES division's programs. A number of earlier major efforts were directly tied to the larger electricity demand that utilities anticipated for the future. Project UHV, for example, was a continuation of work began in the 1960s by the Electric Research Council to establish design criteria for the long-distance, ultrahigh-voltage transmission systems that the industry expected would be needed by the late 1980s. Now it seems that ultrahigh voltage will not be arriving so soon. This project, and many of the other projects aimed at delivering larger amounts of electricity, have now been completed; the findings await the day when the economy and electricity load growth improve.

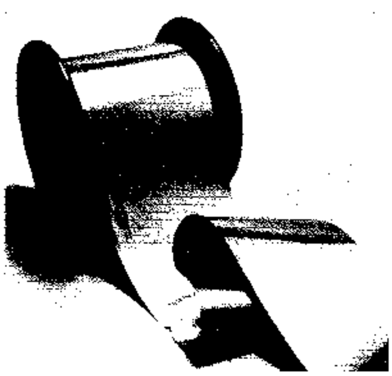
Top priority now goes to projects that deal with improving existing systems. Upgrading transmission lines, towers, and foundations so they can carry electricity more efficiently and economically is one such immediate concern. EPRI's new Transmission Line Mechanical Research Facility, which opened this past year near Fort Worth, Texas, will permit EPRI and member utilities to conduct exhaustive tests of the strength of towers, poles, foundations, and conductors to find the most reliable, lowest-cost designs. The facility includes a two-mile tower and conductor transmission test system, an area for testing tower foundations, and a group of cable-pull towers for measuring the response of tower components and conductors to static and dynamic loads. As information is collected on which designs are best, computer programs will be written for utilities to use in transmission system design. By incorporating these design innovations into existing or new transmission systems, utilities will enjoy improved efficiency and economy. Meanwhile, the division's underground transmission program is developing a new tape laminate that can significantly reduce installation costs for underground pipe-type cable. Because



Improving electrical equipment is central to upgrading the efficiency of today's systems.



The Transmission Line Mechanical Research Facility, near Fort Worth, Texas, will identify reliable, low-cost transmission system designs.



New amorphous metals with excellent magnetic properties offer the possibility of a 60% reduction in transformer core losses.

of the laminate's improved dielectric qualities, smaller-diameter cable can be used. This means utilities can upgrade existing cable systems by one or two voltage levels and still fit the upgraded cable into existing piping, saving perhaps 50% of cable installation costs.

Another research area of immediate interest to utilities is that of rotating electrical machinery. Until recently, the division's emphasis in that area was on developing larger generators to keep up with the public's growing demand for electricity. EPRI began work in the early 1970s on a superconducting generator that could achieve higher ratings in a smaller, more easily transported size and weight. The superconducting generator still fascinates utilities, but not for the same reasons. Today this generator is intriguing because it promises better efficiencies and greater stability than conventional generators. EPRI-sponsored testing of a 300-MVA (270-MW) superconducting generator at a utility power plant is scheduled to begin in 1985.

Today's utilities are also trying to improve the efficiency and reliability of the motors that drive power plant draft fans. If just one key motor in a generating unit goes down, the entire unit is out, and the utility has to provide high-cost replacement power to make up the shortfall. Utilities complained that these motors broke down too often and that their efficiencies were too low, so the ES division systematically surveyed some 5000 power plant motors to identify the problems. Motor bearings, stator windings, and rotor cages were shown to be the weak links that instigated motor failures, and research is now under way to improve the reliability and efficiency of this equipment.

Transformers are another area where efficiency improvements can be made in existing T&D systems. One research item of particular interest is amorphous metals for transformer cores. Because of their special properties, these metals hold out the possibility of a 60% reduction in transformer core losses. The division is developing transformer cores made of these amorphous metals, and when the cores are ready, they will be evaluated on utility systems. If the tests prove successful, commercial production of transformers with amorphous metal cores could begin by 1985, and utilities could realize immediate benefits in efficiency.

While the ES division works to cut costs for such capital-intensive equipment as transformers, motors, generators, and transmission lines, improvements for smaller, less capital-intensive devices are not going unnoticed. This is especially true in the distribution area, where savings in many, many individual components and tasks can add up to large savings over the industry's extensive distribution territories. The division is developing a cable plow, a cable follower, and a borer device for installing underground distribution cables. Tree-growth retardants have been developed to reduce the need for trimming branches near overhead distribution wires, and tree-trimming devices are on the list for future development. Antifungal treatments to extend the life of utility poles are also being developed. The results of research projects such as these can assist utilities burdened by rising distribution costs.

Although today's cost-conscious utilities are trying to keep capital investments to a minimum, occasionally a large investment—such as a needed power plant—must be made. Ongoing ES division research can help utilities make the best choice for their money. An example is EPRI's electric generation expansion analysis system computer program (EGEAS), recently tested and released for utility use. This program permits a utility to systematically consider its many generation expansion options through five different analyses with a common data base. The single program is much faster and less expensive than the usual method of running a number of different programs, usually with different data bases, and then trying to combine the results.

Doubtless, at some future time, load growth will again approach its former steady rate. When it does, the research results that tell how to deliver more electricity will be ready and waiting to be used. Until then, better—not bigger—T&D systems are the byword for the ES division. ■

HVDC transmission could soon be an important means of bringing bulk power to congested cities. This compact HVDC converter station prototype is in Queens, New York.

An advanced cable plow called the Scorpion can smoothly install underground distribution cable without trenching and backfilling.

René H. Malès, Director
Energy Analysis and Environment Division

Decision Making in an Age of Uncertainty

Risk is an inescapable part of everyday life in our society. Each of us daily makes dozens of decisions, often unconsciously, that involve weighing the relative risks against potential benefits of a given course of action—even actions as mundane as crossing the street. There are no benefits without risk; trade-offs, or choosing the mix of risks and benefits, are central to human enterprise.

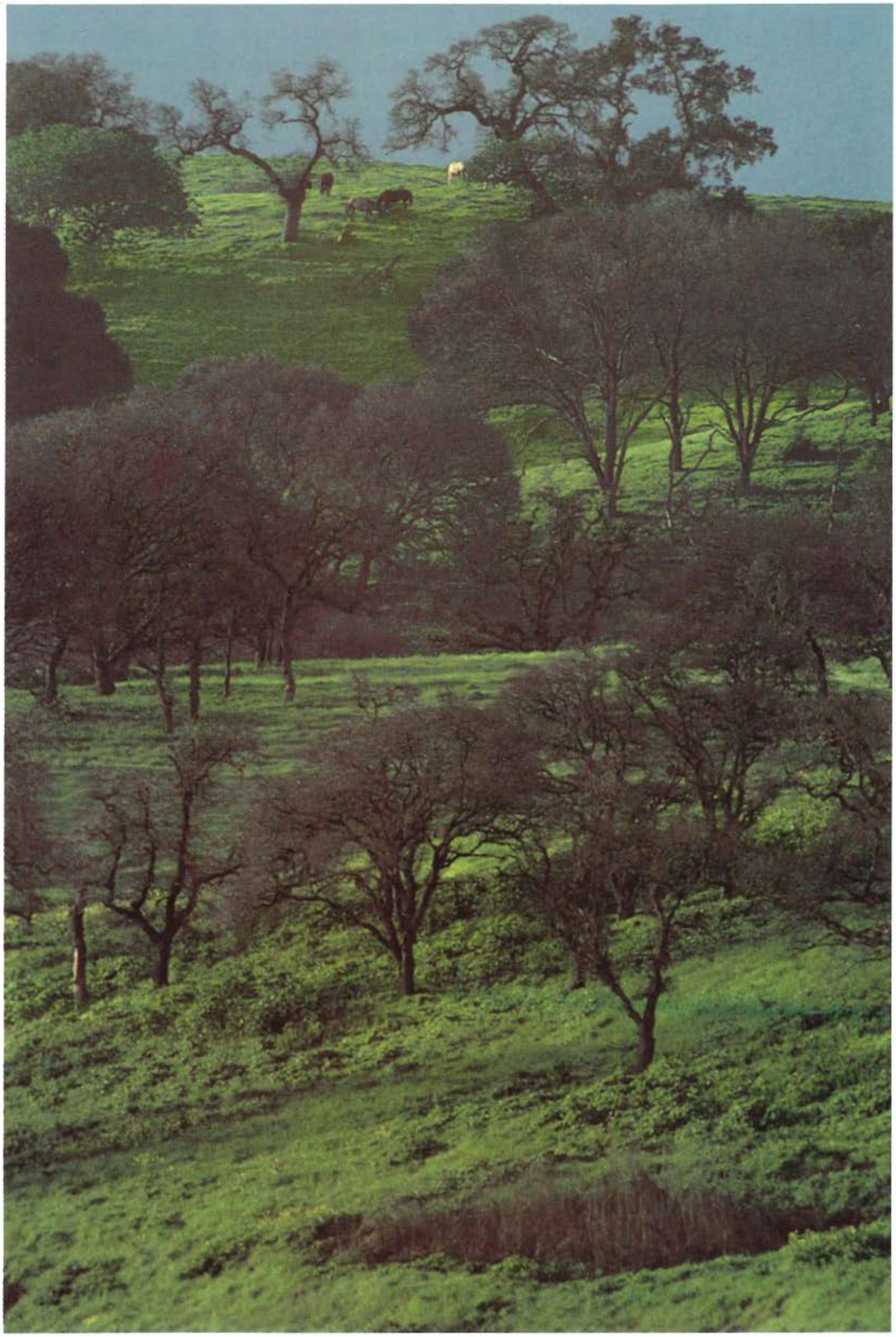
EPRI's Energy Analysis and Environment Division typifies the electric utility industry's commitment to the better understanding of the risks and benefits associated with our society's production and use of energy. The Institute's founders recognized that it is just as important to understand the environment in which energy technology operates as it is to understand the technology itself. By environment, they had in mind not only the physical concerns of air quality, water quality, human health, and public safety but also the energy-economic environment—the amount of energy society will require and the resources that will be available to fill this need.

The importance of these two areas, environmental impact assessment and energy-economic analysis, has not always been obvious, however. In the early days of EPRI, many utilities were unsure of how large a role environmental programs should play in the Institute's overall research effort. And some areas of economic research were seen as esoteric, somewhat remote from the day-to-day task of meeting the demand for electricity reliably and efficiently. But the economic realities signaled by the oil traumas of the 1970s and the arrival of the environmental ethic as a permanent fixture on the political horizon underscored the critical nature of these research fields in determining the shape and pace of change in the industry's future.

The division's research scope and priorities have broadened over the years in response to these pressures. When first organized in 1974 as the Energy Systems, Environment, and Conservation Division, the focus was on providing data and analysis support for other EPRI technical and planning divisions. This remains an important function.

By 1976, however, it was clear that research questions on which the division was focused had become equally important from a policy perspective of the industry at large. What would likely be the demand for electricity in 5, 10, or 20 years? What was the contribution of power plants to ambient air pollution levels? What would the cost and availability of oil or coal resources likely be in the future, and how would this affect the industry's ability to use these resources? As division research became more directly applicable to industry policy-making, EPRI emerged as an authoritative source of objective analysis in environmental, demand, and resource assessment; but the development and advocacy of industry policy positions remained with individual utilities and their associations.

Over the decade the analytic demands on individual utilities grew exponentially, and a third dimension of responsibility



Environmental assessment is a growing part of EPRI's R&D program.

became evident. The planning tools used by utilities in the 1960s were no longer sufficient in an era of great uncertainty, fuel supply disruptions, price fluctuations, and other complex problems involving factors beyond the utilities' control. The Energy Analysis and Environment Division soon became a major source of data and decision-making tools that member utilities could apply to their own problems and strategic planning.

The uncertainties that surround such concerns as the availability and cost of primary energy fuels, the growth rate of electricity demand, and the effects of conservation and load management in changing patterns of electricity use are critical in the minds of utility planners on whose projections may ride billions of dollars in operating costs and new plant investment.

More detailed knowledge of regional air quality will come from continued study of sulfur dioxide and other compounds in the atmosphere.

The division's Energy Analysis Department addresses these concerns by developing analytic tools to help utilities make more accurate forecasts of demand, resources, and financing. Absolute certainty about demand and the role of supply technologies in the future can never be achieved. However, sophisticated analytic techniques can lower the risk of major capital investment by estimating and even explicitly taking into account the bounds of uncertainty.

A widely used example of the kind of planning tool developed for the utility industry by the Energy Analysis Department is the over/under capacity planning model, which takes account of uncertainty in estimating the costs and benefits to utilities and consumers of different levels of capacity expansion. With the EPRI model, utility managers and government regulators are better able to focus on a strategy that optimizes the interests of both the utilities and their customers.

Developing a sound, factual basis on which to assess the impacts of electricity production is the mission of the division's Environmental Assessment Department. Its job, stated another way, is to separate science from emotion. With this information in hand, utilities can foster regulation based on this science. The analytic approach used is a step-by-step examination to identify and characterize power plant emissions, understand the pathways and mechanisms by which energy production by-products enter the environment, and define dose-response relationships in order to measure the relative hazards of substances to humans and the environment.

Today, over half of all EPRI-supported R&D is directly or indirectly related to protecting the environment and human health, either as part of the effort to define the fact base for environmental assessment or in developing new technology to control the effects of energy production.

In some cases EPRI's environmental research has identified deficiencies in data or analysis that have been the basis of proposed new regulatory standards. The division's reanalysis of the federal government's Community Health and Environmental Surveillance System research is such an example. The reanalysis showed that there was no clear association between airborne sulfur dioxide (SO_2) concentrations and human health effects in the studies on which regulations were based. This allowed utilities to avoid unnecessary and unfounded new rules.

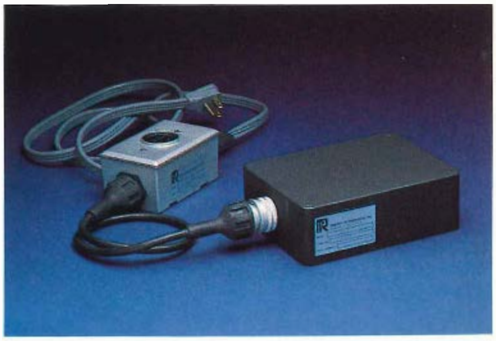
Important to the division as well as to EPRI's members is identifying major new issues of research or regulation in sufficient time for the industry to respond with a credible, informed voice. One example in which the division is already working to keep the industry ahead of the pace of regulatory change involves the phenomenon of acidic deposition and the role of power plant emissions.

Concern over acidic precipitation will likely be the driving force behind the next round of revisions to the Clean Air Act. To ensure that the industry remains at the leading edge of knowledge of the problem and possible remedies, EPRI has made acidic deposition its most important area of environmental research over the next five years. The division expects to manage about $70 million in studies through 1987 that will allow the nation's utilities to contribute constructively to the developing international scientific and government policy debate.

Another major environmental issue emerging in the 1980s in which EPRI is playing a pathfinder role is solid-waste disposal. As better technology permits the removal of ever more pollutants from fossil fuels before they reach the stack, the task of properly disposing of solid wastes grows proportionately. EPRI is already spending $1.5 million a year in this area and expects to roughly triple that level in the next few years.

To all but the most extreme element in the environmental movement, the concept of zero environmental discharge from the large-scale conversion of primary fuels to electricity is wholly unrealistic as a practical, achievable goal in this society. The only alternative is for us to seek a rational balance between the cost of increased environmental control and reduced environmental effects. Within the context of a cost-benefit approach to environmental stewardship, informed priorities are the key to rational decisions. The Energy Analysis and Environment Division's research program is committed to keeping the facts straight, the debate informed, and the policy tools effective and constructive as we seek that balance. ■

New modeling techniques are aimed at reducing the uncertainty in future electricity demand forecasts.



The electric ARM system records household use patterns to assist in developing forecasts and load management programs.

A comprehensive research program on the sources and effects of acidic precipitation is furthering scientific understanding of this complex process.

Fritz R. Kalhammer, Director
Energy Management and Utilization Division

Matching Supply and Demand

The Energy Management and Utilization Division has a unique role within EPRI. While the other "hardware" divisions of the Institute are primarily directed toward developing technologies in bulk electricity supply and distribution, the EMU division's broad goal is to provide improved and entirely new ways of matching energy supply to demand. Improving this match—providing better energy management—can be expected to result in significant economic benefits for utilities and their customers.

Central to the division's goal is the recognition that significant opportunities exist for improving energy management on both sides of the utility meter. On the utility side, these opportunities include development and introduction of more-efficient and versatile generating and storage technologies; on the customer side, better load management and more-productive end-use applications can yield more-compatible and predictable loads for utilities. Emphasis on the end use of electricity deepened in recent years as it became apparent that the greatest potential for improving overall energy system efficiency can be found in the way individual customers use electricity.

The division's work in energy management and utilization takes on added significance today as it responds to some of the utility industry's most pressing near-term problems: the high cost and long lead time of power plant construction; the serious economic penalties imposed by under-using existing plant capacity; the high cost of fuels for producing power at peak demand; the great uncertainties in predicting future demand; and the underlying economic problems facing major electricity consumers, especially the steel and other energy-intensive industries.

Development and commercialization of such technologies as fuel cells, compressed-air energy storage, batteries, and low-head hydro promise to give utilities new ways to manage electricity supply. On the demand side, utilities and consumers will benefit from developments that include improved heat pumps, heat and cool storage technologies, load-control logic, and passive and active solar systems; more-efficient designs and controls for electric motors and for optimizing cogeneration; and advanced applications of electricity in such forms as plasma induction, microwaves, and lasers to increase productivity in crucial industrial processes. EPRI's efforts to develop and evaluate electric vehicle systems and components are also centered within the division.

Fuel cell technology exemplifies the progress by the division in developing new ways utilities can match supply to demand. When commercialized later this decade, fuel cells will offer utilities the most efficient and cleanest generating option available—the first truly new power technology since nuclear. Moreover, because fuel cells have excellent operating response as well as negligible emissions and can be manufactured in relatively small sizes, they will give utilities an unprecedented degree of flexibility in procurement, siting, and operation—

Hydrogen recombiners, part of a lead-acid battery used in testing advanced battery designs at EPRI's BEST Facility.

all of which will help utilities to better match electricity supply to demand.

Pumped storage of hydroelectric power in a reservoir near a dam can be an effective means of storing off-peak energy for later use.

Fuel cells have been under development for more than 10 years. Their evolution over two decades—one past and one ahead—is characteristic of the long lead times required to develop new energy technologies and bring them to the marketplace. It also attests to how critical program continuity and stability are to the RD&D process and to the eventual commercialization of new energy technologies. EPRI has been a major factor in providing this continuity, and the division has worked closely with the Fuel Cell Users Group of electric utilities as it advances utility understanding of the benefits and uses of this new option. The Users Group also helps identify potential early users and their needs, and it encourages manufacturers to develop the technology by strengthening their confidence in a waiting market.

The division's efforts to advance electric heat pump technology and applications illustrate the technical progress and the commercialization issues associated with developing new technologies on the end-use side of the meter. Heat pumps have, of course, been commercially available for a number of years. But they are not as efficient as customers would like in reducing electricity bills, and they are least efficient at exactly the times utilities need efficiency the most—on the coldest and hottest days of the year. Moreover, there is no incentive at present for heat pump manufacturers to develop equipment with better peak demand efficiencies because most utility customers do not pay a premium for power at peak periods.

Electric heat pump R&D is focused on improving year-round performance for greater efficiency in residential end use of energy.

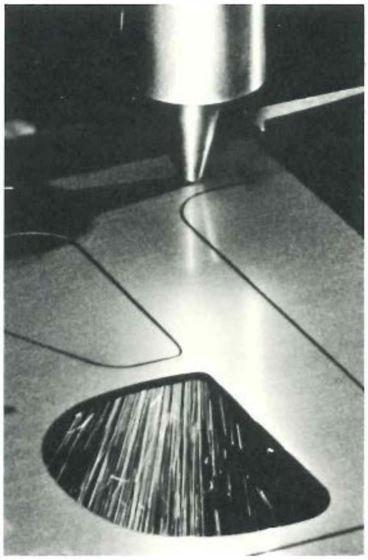
To address these issues, the division is working with heat pump manufacturers to share the risk of developing more-efficient equipment that will benefit utilities and customers equally. By 1985–1986 this program should result in prototypes of heat pumps with significantly higher efficiencies and better peak demand characteristics than those now in wide use.

One of the newest and most promising directions in the division's end-use work is the exploration and advancement of new uses of electricity to increase industrial productivity. The close historical correlation between industrial electricity use and GNP shows that electricity use and productivity are tied together very closely, and emerging new electric technologies can be expected to sustain this tie.

Examples of promising new technology applications include high-temperature electric plasmas for improved steelmaking, metals fabrication, and perhaps chemical synthesis; laser-based electrochemical systems and electric discharges for difficult or high-speed machining jobs; microwave and radio frequency energy for more rapid and efficient heating, drying, and other materials processing steps; electric separation processes; and other applications now limited more by conventional thinking than by technical constraints.

A survey of the division's plans and prospects for new developments in energy supply and end use reveals that several important milestones should be reached in this decade: to install the first commercial fuel cell power plants and compressed-air storage systems; demonstrate lower-cost approaches to small hydro; establish the viability of battery energy storage on the 5–10-MWh level in the Battery Energy Storage Test Facility; produce prototypes of heat pumps operating at 40–50% higher efficiency than units now in service; and demonstrate advanced, cost-effective electronic speed control techniques that permit significant energy savings in utility and industry-commercial service. Also anticipated are the development and validation of improved and broadened approaches to load management, as well as new applications of electricity and their associated productivity gains in major energy-consuming industrial sectors.

In a natural progression of activities to improve energy management on both sides of the meter, the division expects to play an important role in the future in identifying, developing, and helping utilities capture the synergistic advantages of combined supply side and end-use management technologies and systems. Individually, these technologies and systems clearly hold great promise for utilities and their customers. And beyond this, they can be deployed and dispatched, in combination and across the meter, to achieve even greater efficiencies and economies. ■



Innovative electrification technologies promise significant efficiency and productivity gains in a number of basic industrial processes.

A catalytic steam reformer converts fuel and steam to hydrogen for powering the 4.8-MW fuel cell demonstration in Manhattan.

John J. Taylor, Director
Nuclear Power Division

Focus on Safety and Reliability

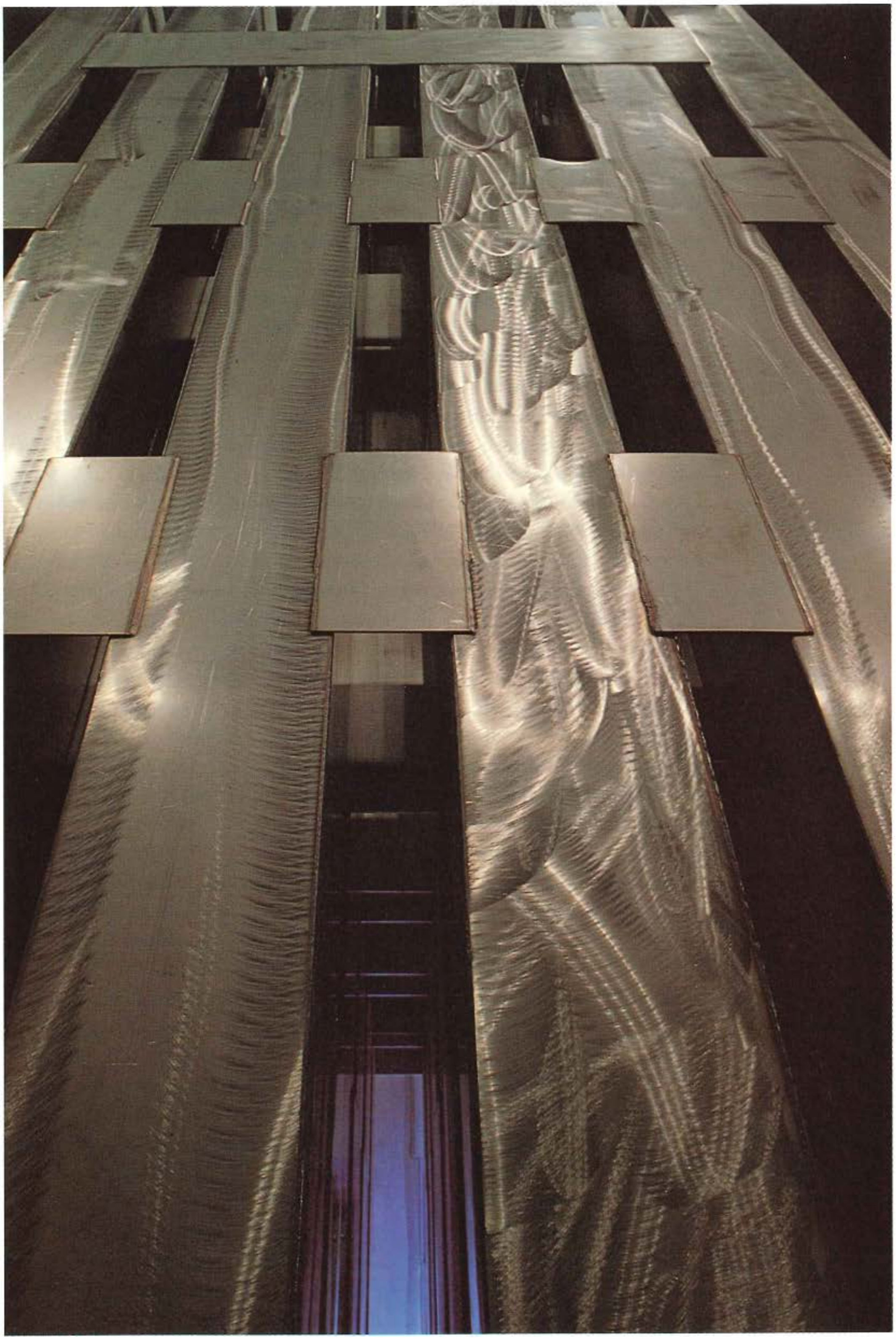
Slackening electricity demand, increases in the cost of operating and constructing nuclear plants, and shifts in public attitude away from nuclear power have altered the nuclear industry's research agenda in recent years. Before the division can place major effort on the next generation of nuclear power—liquid metal fast breeder reactors, advanced light water reactors, and nuclear cogeneration with both gas- and water-cooled reactors—the safety, reliability, and economy of today's plants must be improved. Through aggressive research programs, the division is striving to do just that.

Some 79 operating nuclear power plants have a collective capacity of 60 GW (e) and produce 12% of the nation's electricity. In parts of the United States, nuclear's contribution approaches or exceeds 50%. This electricity is produced at lower cost than the electricity from coal or oil plants that utilities would have to use as alternatives. By 1992 the nation's nuclear power capacity will reach 20% as plants well along in construction come on-line. Nuclear power's substantial contribution to the U.S. electricity supply makes it imperative that the nuclear option remain open.

Yet in recent years the industry has encountered unexpected reliability concerns at existing plants, which in turn have led to concerns about the future economic competitiveness of the industry. Reliability problems, such as steam generator corrosion in PWRs and pipe cracking in BWRs, strain the economics of the nuclear industry. When a plant must be shut down for repairs, the owner utility must pay $500,000–$1,000,000 a day for replacement power. The repair bills in themselves are costly, such as the $100–$300 million price tag on a new steam generator. The imposing dollar investments required to keep a nuclear plant up and running demand assiduous caretaking—and equally assiduous EPRI research into ways of improving reliability.

Licensing issues, too, have taxed the economics of the nuclear power industry. Even before the accident at Three Mile Island, the nuclear power industry had put extensive funding into safety studies and safety provisions. TMI has reemphasized these safety issues, and significant improvements have been made in existing plants that reflect the lessons learned from TMI. These improvements have been achieved at substantial expense—about $30 million per plant. As with reliability issues, continued research is necessary to optimize nuclear plant safety, as well as to define and stabilize licensing requirements. This research and the improvements coming from it should also serve to reassure the public. Before the 1979 accident, more than 60% of the U.S. public favored building additional nuclear plants; since then, public enthusiasm has dimmed to the point where only 40% of the population favors construction of more nuclear plants.

Slackening electricity demand, the increased cost of keeping nuclear plants running, and changing public attitudes have plainly led to a pause in the nuclear power industry's expansion. No new plants have been ordered in the United States since 1978, and there



Spent-fuel storage racks.

have been numerous delays and cancellations of plants previously planned. Because only so many research dollars are available, more and more of today's dollars are being invested in improving future prospects for nuclear power by improving the safety and reliability of existing plants. The division now entrusts over 95% of its funds toward that goal.

The division's research focus on safety and reliability issues can be seen in its response to Three Mile Island. The division's Nuclear Safety Analysis Center (NSAC) was organized to evaluate TMI and other nuclear power plant operating experiences and to identify possible problems that might precede serious accidents. NSAC's Notepad telecommunication system, which provides utilities with continuous updates on safety issues at plants, is just one example of how utilities are being kept informed. EPRI has turned the Notepad system over to the Institute of Nuclear Power Operations and is working closely with INPO to improve plant operating procedures and emergency response plans. These efforts will help assure the public of the continuing safety of nuclear power plants.

A high-power, compact X-ray source, nicknamed Minac, fulfills specialized inspection requirements.

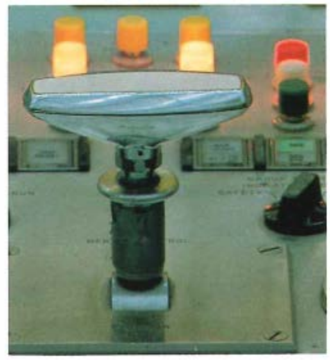
Another important safety R&D program in the division involves potential accidental radioactive releases from nuclear power plants. TMI's radioiodine gas releases were much lower than had been predicted, and observers theorized that when radioiodine is produced, it takes the form of cesium iodide, which is a salt, not a gas. Salts dissolve in the reactor's coolant water and are eventually deposited on the surfaces of plant equipment and structures. They are thus more easily contained than gases. The division is now participating in a major research program to verify this information and determine its applicability to all nuclear plants. If theory proves to be fact, emergency response planning for plant accidents and community anxieties about those accidents can be significantly reduced.

Because the continued viability of the nuclear power industry demands major improvements in plant reliability, the division has extensive work under way in that area—work which is closely coordinated with the nuclear industry. The tube support plates of many PWR steam generators, for example, were found to be corroding more quickly than anticipated, forcing untimely and costly outages to plug or sleeve generator tubes and to repair or replace generators. The Steam Generator Owners Group, sponsored at EPRI by the nuclear utilities, marshalled an extensive research program in 1977 to uncover the causes of this corrosion and its solutions. The group identified contaminated steam generator feedwater as the root of the corrosion and prescribed solutions that include minimizing condenser tube leakage, reducing oxygen leaks into the feedwater, improving feedwater chemistry controls, and adding boric acid to the feedwater to inhibit further corrosion. The manufacturers have also identified ways to make their equipment less susceptible to such corrosion and other forms of deterioration. By following these prescriptions, PWRs may live out their licensed lifetimes, avoiding millions of dollars in replacement power costs and steam generator repairs.

Another major reliability area where EPRI research will fortify the industry is BWR pipe cracking. The BWR Owners Group was formed at EPRI to find the solution to the persistent problem of intergranular stress corrosion cracking (IGSCC) in BWR piping. An extensive test program identified IGSCC-resistant stainless steels for piping, the steels were accepted by NRC as an effective remedy, and new piping is being adopted in BWRs under construction. Methods of improving the IGSCC resistance of existing piping through stress relief and repair techniques were also developed, and the program demonstrated that the regular addition of hydrogen to reactor feedwater could significantly suppress oxygen-activated IGSCC; further testing will identify any side effects that this treatment may have.

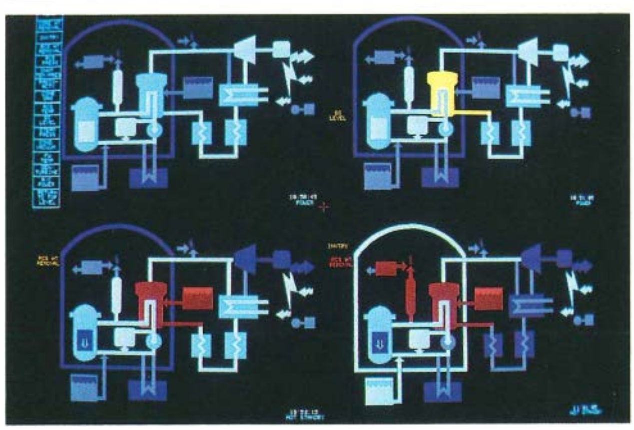
The reliability of nuclear power plants can also be improved by better nondestructive evaluation—the testing that identifies incipient flaws in power plants and provides diagnoses of whether equipment should be run, repaired, or replaced. The Nuclear Power Division is developing improved NDE tools and techniques, including automated ultrasound and eddy-current systems and a high-power, lightweight X-ray source. EPRI has also established the NDE Center in Charlotte, North Carolina, to turn out field-ready equipment and procedures, as well as technicians trained to use this equipment in a power plant environment.

Nuclear power has much to offer the nation. Not only has nuclear-generated electricity been relatively inexpensive, but the environmental effects of the total process of generating electricity from nuclear energy have been relatively benign. Because of these assets, the United States has come to rely on nuclear power for an important part of its electricity. Selective R&D can ensure the continued safety, reliability, and economy of this industry, and by confirming the near-term promise of this energy resource, nuclear's larger, long-term promise can be realized. ■

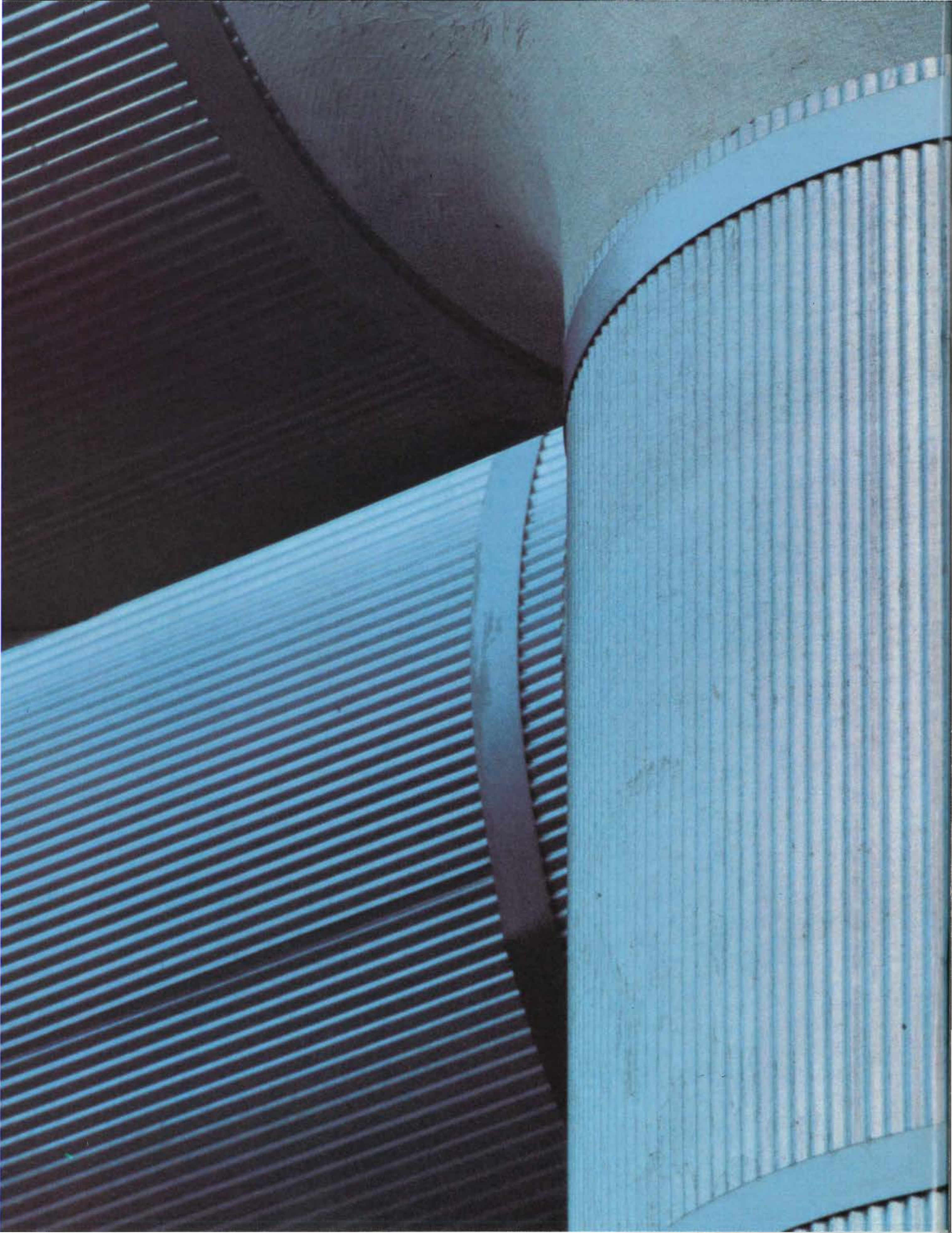


Research on human factors, such as control room design, helps ensure the safe operation of nuclear plants.

The PWR safety and relief valve test program satisfactorily demonstrated component operability under a range of full-scale conditions.



The major safety and availability functions of a nuclear power plant are displayed on the disturbance analysis and surveillance system.



TECHNOLOGY TRANSFER

A review of Institute activities and initiatives to facilitate the use of R&D results by the electric utility industry

Richard L. Rudman, Director
Information Services Group

EPRI is moving aggressively to encourage transfer of technology to the electric utility industry. From project initiation through end use of R&D results, efforts are being focused on this critical activity. Product licensing, software packaging and development, on-line information, streamlined technical reports—these efforts reflect a deepening commitment to see that the results of EPRI's work are used.

Technology transfer ranks high in priority for 1983, EPRI's 10th anniversary year. For instance, EPRI expects to execute as many commercial hardware licensing agreements during the coming year as it has during its entire previous existence.

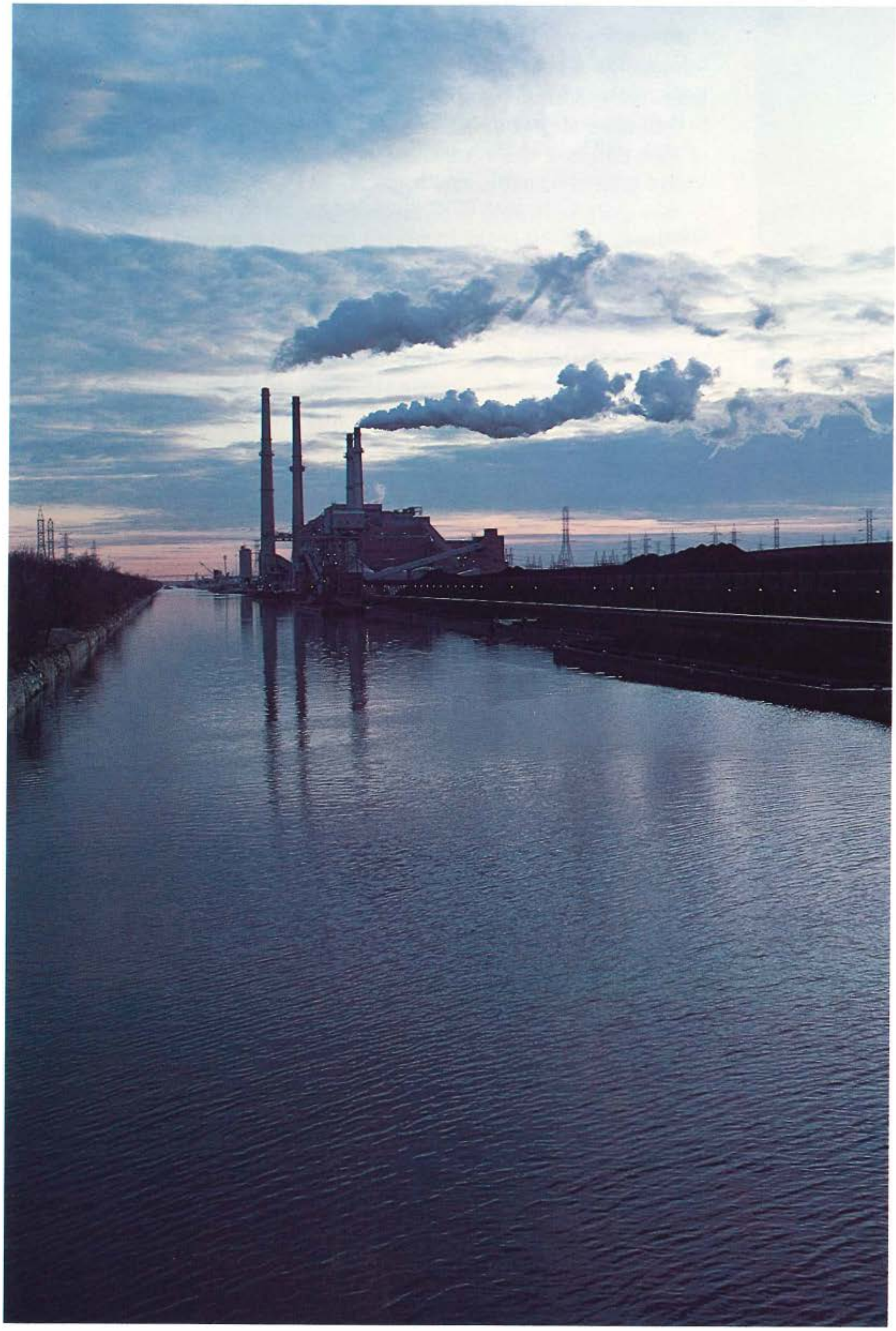
The past year, 1982, shows evidence of this stepped-up emphasis. A partial list of licenses issued includes the Electric ARM, a device for monitoring household electricity consumption; the Horiba portable detector for determining whether transformers, circuit breakers, and related equipment need further analysis for PCB contamination; and Minac, a miniature linear accelerator for making internal X-ray inspections of weldments in operating nuclear plants.

Such products represent only a portion of EPRI-developed components, techniques, and processes. Devices that probe generating systems for leaking valves and cracked metal, redesign of equipment to reduce the environmental impact of transmission and distribution facilities, and new testing instruments that eliminate costly shutdowns are all examples of recent applications. The increase in EPRI R&D results can be seen in a tripling of published industry application reports over the past three years. In addition, seven Institute-sponsored research centers, established to test and demonstrate new components and systems and train utility personnel in their use, contribute to technology transfer.

Some 70 EPRI software packages produced by the Institute's six technical divisions are now available to member utilities. These computer programs cover a broad spectrum of interests—from simulating wind power plant performance, to analyzing load management options, to evaluating safety conditions at nuclear power plants. Two popular EPRI software programs are the over/under capacity planning model, a cost-benefit decision-making tool for calculating generation reserve requirements, and STEALTH, a program used in the design and analysis of nuclear reactors.

The Institute's Electric Power Software Center, which distributes EPRI computer programs to member utilities and other licensees, moved to Dallas, Texas, in 1982. EPSC's companion—the Electric Power Service Bureau—eliminates the need for an in-house large mainframe computer to run EPRI programs. For the first time a telecommunicating desktop computer can be used to call up most Institute programs, a development expected to hasten the transfer of EPRI software to both large and small utility members.

But hardware and software are only part of the story. In the broadest sense, technology transfer means information transfer.

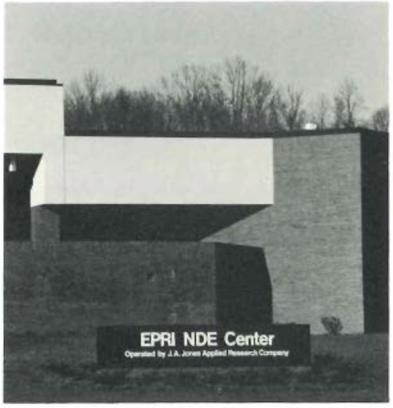


EPRI's emphasis on near-term R&D is accelerating the flow of research results to the electric power industry.

The most innovative scientific advances may languish if inadequately communicated to potential users. Accordingly, the Institute plans extensive refinement in the distribution and presentation of its technical information. Reader profiles will ensure that individuals and institutions receive only those documents that have been specifically targeted to their interests and needs. Single-sheet summaries, to be introduced in 1983, will help readers decide whether to pursue a given subject before requesting a full-length report.

In 1982 EPRI extended the reach of the Electric Power Database, the heart of the Institute's technical information system. Updated monthly, EPD is now available through DIALOG information service, allowing computer terminal access to nearly 9000 ongoing and completed research projects sponsored by EPRI and utilities across the United States. DIALOG's flexibility and power have already been reflected in substantially increased hours logged by EPD users. Also established in 1982 was a telephone hotline (415 855-2411) to EPRI's Technical Information Center, permitting those without telecommunication terminals to request EPD searches or project information.

Videotapes, programmed learning packages, multimedia slide presentations, and other communication techniques are being employed to encourage wider utility use of Institute work. Recognizing the value of person-to-person information exchange, EPRI's Electrical Systems Division in 1983 plans a series of regional workshops across the country, with members of Institute advisory com-



One of seven EPRI facilities across the nation that test advanced equipment and procedures and bring together the researcher and the utility engineer.

Distribution of reports, summaries, and collateral material is being streamlined, and technical information is soon to be targeted to the individual reader's interests and needs.

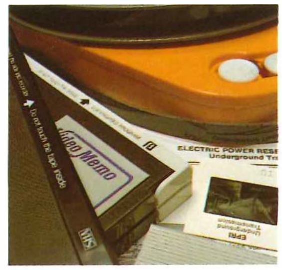
EPRI now holds hundreds of patents and is stepping up its emphasis on licensing agreements to speed the development of commercial products.

mittees as workshop leaders. If successful, the initial series of information-exchange meetings may well become another Institute-wide technology transfer effort.

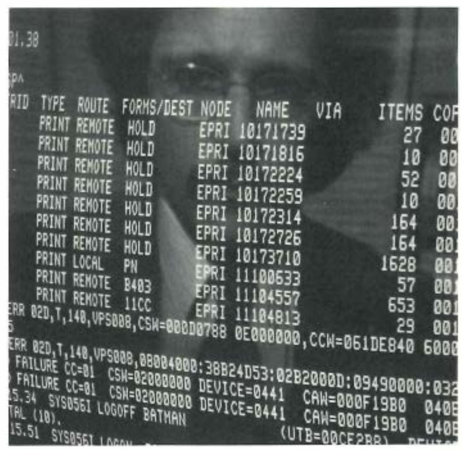
Clearly, the Institute's approach to technology transfer is more diverse, more experimental, than may be the case several years hence. EPRI's present Technology Transfer Committee, for example, simultaneously serves as an interchange point for new methods and ideas, as an advisory body for technology transfer policymaking, and as a resource for Institute managers in developing transfer plans for proposed projects.

In many respects, EPRI's varied membership virtually commands such a diffuse, highly individualized approach to technology transfer. Moreover, the nature of technologies themselves may render rigid formulas for their transfer of little use—a specific technology transfer strategy must be tailored to fit each new product. The final approach to commercialization will depend on such considerations as the type of product (hardware, software, or information), its cost, and the number and type of potential users.

Technology transfer is a shared responsibility, one that may encompass a contractor, a manufacturer, and, always, the utility end user in addition to the Institute. With the variety of alternatives being explored as it begins a second decade, EPRI believes the first steps toward success in this important field are being taken. In the end, the goal for technology transfer is identical to that for any EPRI R&D endeavor: to make a useful impact on those it serves. ■

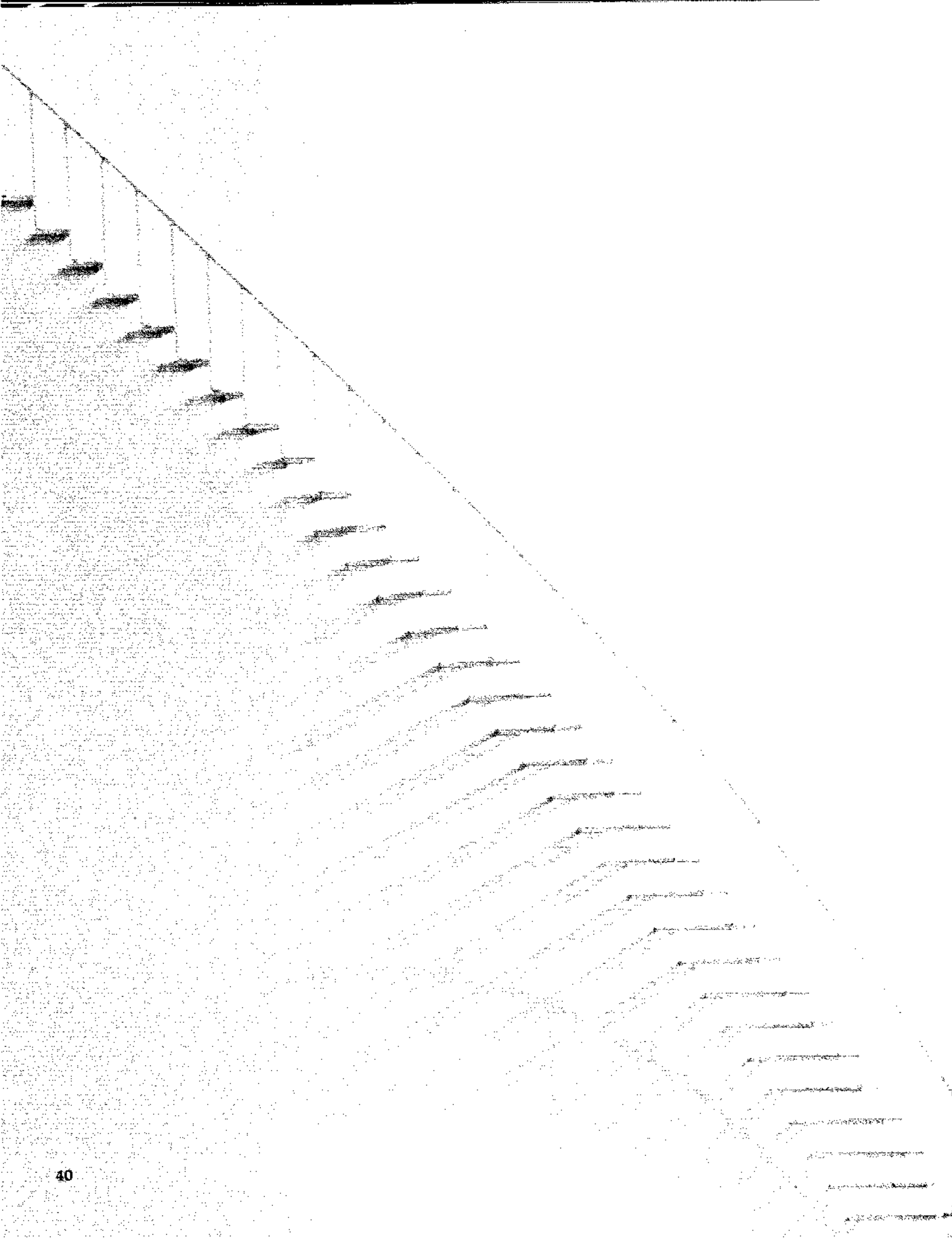


Films, videotapes, and multimedia slide presentations lend immediacy to technical topics and make them more accessible to wide audiences.

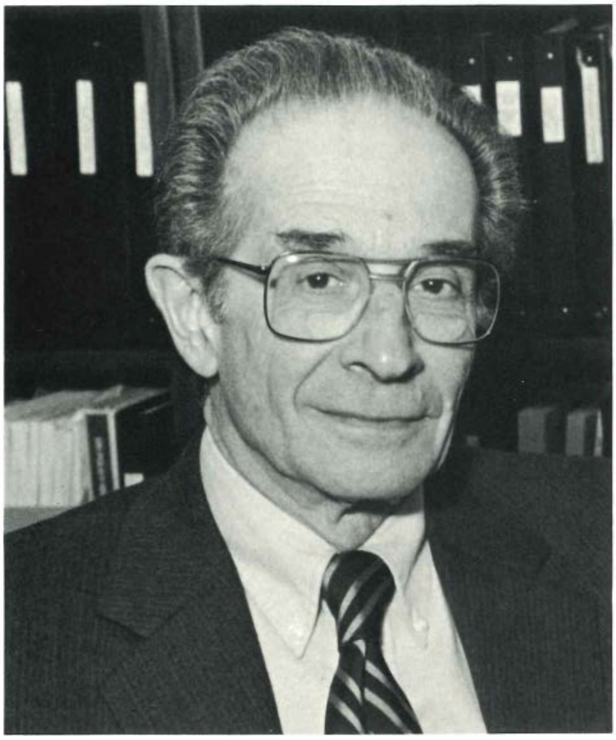


On-line computer access to 9000 electric power research projects is now available through the DIALOG system.

Person-to-person contact through workshops, seminars, consultations, and even the telephone remains the most effective means of transferring technology.

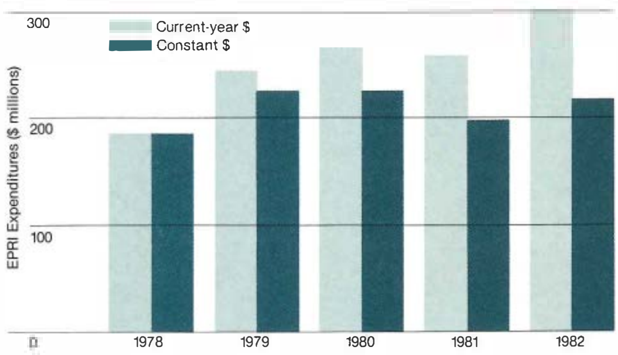


OPERATIONS AND FINANCE



David Saxe, Vice President
Finance and Operations Group

Expenditures in 1982 increased by $44 million over 1981. In real terms, however, after adjusting for inflation the EPRI program has been essentially level for the five-year period from 1978 through 1982 shown in the graph. During this period, EPRI implemented a revised financing policy that resulted in generally declining year-end fund balances. Previously, the policy called for the funding of all outstanding contract commitments, which led to the accumulation of a substantial year-end fund balance. The decision to fund EPRI on a cash-required basis allowed industry payments to be scheduled as closely as possible to actual cash needs. The year-end fund balance has declined as follows: $95 million in 1978; $46 million in 1979; $5 million in 1980; and $12 million in 1981. A $7 million negative fund balance at December 31, 1982, results largely from costs incurred by contractors but not yet billed to the Institute. Offsetting these payables, but not included in the 1982 year-end Statement of Financial Position, are the commitments from members for 1983 dues payments.



At the end of 1982 EPRI's members totaled 508. The membership consists of 134 investor-owned utilities, including their affiliates and service organizations; 178 municipal or regional government utilities; 194 rural electric cooperatives; and 2 federal systems, the Tennessee Valley Authority and the Bonneville Power Administration. Nonmember utilities who contributed in some measure to EPRI's support in 1982 totaled 144.

The full-time EPRI staff was 730 at year-end, up slightly from 697 the previous year. Of the 1982 total, 357 are technical professionals, including 12 on loan to the Institute from utilities and manufacturers.

Outlook

For 1983 the Board of Directors has established a budget of $326 million for EPRI's total expenditures (excluding the separately funded programs). Of this amount, $270 million is forecast for R&D contract costs.

Member payments are estimated at $277 million and other income at $8 million for a total of $285 million. The payments required for membership were originally set in August 1982. As a result of the declining inflation rates, EPRI's management advised the Board of Directors that the planned program could probably be accomplished at less cost than previously anticipated and proposed that the membership payment rate be reduced by 5%. That proposal was adopted by the Board at its December meeting.

The transfer of R&D results from EPRI to its utility members, suppliers, and the public will receive increased emphasis in 1983. Staff activities devoted to commercialization and utilization of new technology will show a moderate increase, and the total staff is expected to grow by about 3%.

Technical Divisions

The major responsibilities and 1982 R&D expenditures of EPRI's six technical divisions are as follows.

☐ The Advanced Power Systems Division sponsors research in the development of coal-derived fuels and technologies and manages research on renewable resources. $56 million.

☐ The Coal Combustion Systems Division R&D program focuses on the resources, operations, emission controls, and waste disposal aspects of conventional and advanced coal-fired power plants. $48 million.

☐ The Electrical Systems Division conducts R&D on the design, performance, and maintenance of power transmission and distribution systems and rotating electrical machinery. $35 million.

☐ The Energy Analysis and Environment Division develops energy planning methodologies, performs economic analyses, and directs research on the environmental effects of electric utility operations. $33 million.

☐ The Energy Management and Utilization Division sponsors R&D related to storage, conservation, and efficient conversion of electric energy. $24 million.

☐ The Nuclear Power Division manages research on the safety, efficiency, maintenance, and availability of nuclear reactors and auxiliary systems. $59 million.

Separately Funded Programs

There are six EPRI R&D activities that receive all or part of their funding from other organizations. Their activities and 1982 R&D expenditures are as follows.

☐ The Nuclear Safety Analysis Center (NSAC), managed by the Nuclear Power Division, was established to probe the Three Mile Island accident and generic safety issues of nuclear reactors. Beginning in 1983, the main portion of NSAC funds will come from the Nuclear Power Division budget. $7 million.

☐ The Intergranular Stress Corrosion Cracking Program focuses on preventing and remedying problems in boiling water reactor (BWR) recirculation piping systems. A major water chemistry study on hydrogen formation in reactor cooling water was begun in 1982. $8 million.

☐ The Steam Generator Program sponsors research on problems that limit the performance and availability of pressurized water reactor (PWR) steam generators. $9 million.

☐ The PWR Safety and Relief Valve Program was completed in 1982 after full-scale testing of reactor safety and relief valves. Results of the research have been transmitted to the Nuclear Regulatory Commission, and utilities are using the test data to evaluate valve performance of individual plants. $2 million.

☐ The Utility Acid Precipitation Study Program has established a network of 20 monitoring stations in the eastern United States. Collection and analysis of the data have begun with the sponsorship of 35 utilities in the region. $1 million.

☐ The Nuclear Fuel Industry Research Program was established in 1982 to conduct generally applicable basic research on nuclear fuel and other core materials. The international cooperative program includes European as well as U.S. utilities, reactor manufacturers, and nuclear fuel suppliers. Collection of funds began in 1982, with R&D expenditures to follow in 1983.

Facilities

Seven specialized facilities under long-term contract or owned by EPRI are now in operation at various locations around the United States. In June the Coal Cleaning Test Facility, located in Homer City, Pennsylvania, was dedicated. CCTF will develop and demonstrate optimal coal-cleaning equipment and processes. In September the Transmission Line Mechanical Research Facility in Haslet, Texas, was dedicated. TLMRF will serve as a center for national research aimed at improving existing transmission towers and designing new ones.

These new facilities join five others already in operation: the Nondestructive Evaluation Center in Charlotte, North Carolina; the Underground Cable Test Facility at Waltz Mill, Pennsylvania; the High-Voltage Transmission Research Facility at Lenox, Massachusetts; the Battery Energy Storage Test Facility in Hillsborough Township, New Jersey; and the Emissions Control and Test Facility at Denver, Colorado, which tests new environmental control equipment by using the gas stream from the Arapahoe coal-fired station of Public Service Co. of Colorado.

Board of Directors and Officers

In April 1982 William R. Gould, chairman and chief executive officer of Southern California Edison Co., was reelected chairman of EPRI for a second one-year term. A. J. Pfister, general manager of the Salt River Project, was elected vice chairman, succeeding Charlie F. Jack, vice president for engineering and power supply, Buckeye Power, Inc., who completed his Board term in April. Floyd W. Lewis, chairman and president of Middle South Utilities, Inc., and Keith L. Turley, chairman and chief executive officer of Arizona Public Service Co., also completed their Board terms in April.

Three new directors elected to the Board in April were Robert N. Cleveland, president of Buckeye Power, Inc.; Charles J. Dougherty, chairman and chief executive officer of Union Electric Co.; and William B. Reed, president of Southern Company Services, Inc.

Laura Huisman was elected comptroller and assistant treasurer of EPRI in 1982. ■

Electric Power Research Institute, Inc.
Statement of Financial Position
December 31 (thousands of dollars)

	1982		1981	
	Base Program	Separately Funded Programs	Base Program	Separately Funded Programs
ASSETS				
Current assets:				
Cash and short-term marketable securities (Note 2)	$ 46,355	$21,217	$ 53,774	$29,770
Amounts due from members	16,649	1,188	22,405	3,380
Accrued interest receivable	300	97	120	255
Other current assets	2,963	996	2,622	63
	66,267	23,498	78,921	33,468
Property, facilities, and equipment (Note 3)	35,468	—	31,267	—
Funds held by trustee (Note 4)	2,555	—	4,185	—
Total assets	104,290	23,498	114,373	33,468
LIABILITIES				
Current liabilities:				
Research and development expenses payable	86,397	7,257	75,799	8,987
Accounts payable and other accrued liabilities	5,052	9,573	5,931	1,672
Current portion of long-term debt and obligations under capital lease (Notes 4 and 5)	1,742	—	1,606	—
Interest payable	86	—	97	—
	93,277	16,830	83,433	10,659
Long-term research and development expenses payable	1,321	65	1,191	69
Long-term debt (Note 4)	12,823		14,521	—
Obligations under capital lease (Note 5)	3,576	—	3,620	—
Total liabilities	110,997	16,895	102,765	10,728
Commitments (Notes 5 and 6)				
FUND BALANCE (DEFICIT)	$ (6,707)	$ 6,603	$ 11,608	$22,740

See accompanying notes to financial statements.

Electric Power Research Institute, Inc.
Statement of Revenues and Expenses and Changes in Fund Balances
Years Ended December 31 (thousands of dollars)

	1982		1981	
	Base Program	Separately Funded Programs	Base Program	Separately Funded Programs
REVENUES				
Industry payments (Note 11)	$275,820	$10,761	$258,389	$39,961
Interest income	7,001	3,412	5,869	4,327
Other income	723	1,671	257	5
Total revenues	283,544	15,844	264,515	44,293
EXPENSES				
Contract research and development (Note 9)	257,840	21,960	218,129	28,825
Program management and in-house research	44,019	10,021	39,685	9,649
Total expenses	301,859	31,981	257,814	38,474
EXCESS (DEFICIENCY) OF REVENUES OVER EXPENSES	(18,315)	(16,137)	6,701	5,819
FUND BALANCE, BEGINNING OF YEAR	11,608	22,740	4,907	16,921
FUND BALANCE (DEFICIT), END OF YEAR	$ (6,707)	$ 6,603	$ 11,608	$22,740

See accompanying notes to financial statements.

Electric Power Research Institute, Inc.
Statement of Changes in Financial Position
Years Ended December 31 (thousands of dollars)

	1982		1981	
	Base Program	Separately Funded Programs	Base Program	Separately Funded Programs
Cash was provided (used) by operations:				
Excess (deficiency) of revenues over expenses	$(18,315)	$(16,137)	$ 6,701	$ 5,819
Add (deduct) items not affecting cash in the period:				
Depreciation	1,864	—	1,139	—
Decrease (increase) in amounts due from members	5,756	2,192	16,930	4,989
Decrease (increase) in other current assets except cash and short-term marketable securities	(521)	(775)	2,225	3
Increase (decrease) in liabilities excluding debt and capital lease	9,838	6,167	1,695	(289)
Total	(1,378)	(8,553)	28,690	10,522
Cash was used for:				
Additions to property, facilities, and equipment	6,065	—	14,050	—
Payment of long-term debt	1,606	—	66	—
Total	7,671	—	14,116	—
Increase (decrease) in cash and short-term marketable securities before financing activities	(9,049)	(8,553)	14,574	10,522
Financing activities:				
Withdrawal from bond trustee	1,630	—	6,729	—
Increase (decrease) in cash and short-term marketable securities	$ (7,419)	$ (8,553)	$21,303	$10,522

See accompanying notes to financial statements.

Electric Power Research Institute, Inc.
Notes to Financial Statements

NOTE 1—Description of organization, mission, and summary of significant accounting policies:

Organization

The Electric Power Research Institute, Inc. (the Institute), was organized in 1972 under the District of Columbia Nonprofit Corporation Act. The mission of the Institute is to conduct a national research and development program relating to the production, transmission, distribution, and utilization of electric energy. The Institute's activities include technological assessment of both near-term and long-term research needs, their arrangement into an orderly strategic plan, the assignment of priorities and allocation of funds, the implementation and management of the resultant projects, which, for the most part, are performed by independent contractors, and dissemination of the information gained. These activities are carried out under the sponsorship of the public, private, and cooperative sectors of the U.S. electric utility industry and constitute the base program for the Institute (Base Program). In addition to the Base Program, the Institute is conducting six separately funded research efforts. These are the Boiling Water Reactor Owners Group Intergranular Stress Corrosion Cracking Program (ISCCP), the Nuclear Safety Analysis Center (NSAC), the Nuclear Fuel Industry Research Program (NFIRP), the Pressurized Water Reactor Safety and Relief Valve Program (RVP), the Steam Generator Owners Group Program (SGP), and the Utility Acid Precipitation Study Program (UAPSP).

Summary of Significant Accounting Policies

The Institute employs the accrual basis of accounting and, accordingly, records contribution commitments as revenue in the year to which the commitment relates; records interest as income when earned; and records contract research and development expenses, program management, and in-house research expenses as they are incurred.

Under some research contracts, the Institute agrees to reimburse its contractors for the cost of specialized equipment needed to perform the work. In such cases, it is the Institute's policy to retain title to such equipment and to charge to expense the cost thereof when such cost is invoiced by the contractor. At the conclusion of the contract, such equipment may be transferred to other work. Otherwise, the proceeds, if any, from the sale or other disposition of the equipment are credited to other income.

The cost of buildings and land leaseholds for use in program management is amortized over the respective lease terms, and depreciation is computed by using the 150% declining-balance method for buildings and the straight-line method for land leaseholds. Equipment and leasehold improvements are capitalized when the acquisition cost of an item exceeds $5,000 and has a useful life greater than one year; depreciation is computed by using the straight-line method over their expected useful lives. Structures and equipment having an individual cost exceeding $250,000 and used in conducting multiple research projects are capitalized, and depreciation is computed by using the straight-line method over their expected useful lives. Costs associated with individual research and development projects conducted at these facilities are charged to expense as incurred.

Program management and in-house research expenses incurred by the Institute are allocated to all research activities, including those that are separately funded.

A reclassification of $5,086,000 from Other Current Assets to Property, Facilities, and Equipment was made in the 1981 statement of financial position for comparative purposes. (See Note 3.)

NOTE 2—Cash and short-term marketable securities:

Cash and short-term marketable securities, at cost that approximates market, comprise the following.

	1982	1981
	(thousands of dollars)	
Cash (net overdraft)	$ 8,058	$ (1,980)
Bankers acceptances and certificates of deposit	13,095	7,889
Commercial paper	46,419	77,635
	$67,572	$83,544

It is the Institute's current policy to solicit contributions for the Base Program from its members each year only for the funds required for that year's total estimated cash disbursements. Through January 31, 1983, members have committed $250,595,000 for 1983 cash disbursements. For 1983, member payments are scheduled to be received in four equal quarterly installments, due in the first month of each quarter.

NOTE 3—Property, facilities, and equipment:

	1982	1981
	(thousands of dollars)	
Buildings and land leases	$26,386	$26,245
Equipment and leasehold improvements	2,308	2,337
Construction in progress	11,039	5,086
	39,733	33,668
Accumulated depreciation and amortization	(4,265)	(2,401)
	$35,468	$31,267

Construction in progress includes $9,264,000 in 1982 and $5,086,000 in 1981 for a research test facility. The facility is expected to be completed in March 1983 and will be used extensively for Institute research over the next 10 years. During 1983, external financing alternatives will be pursued.

NOTE 4—Long-term debt:

	1982	1981
	(thousands of dollars)	
Mortgage	$ 2,156	$ 2,186
Bonds	12,365	13,900
	14,521	16,086
Less current portion	(1,698)	(1,565)
	$12,823	$14,521

The mortgage loan is secured by a deed of trust on one of the buildings, which has an aggregate cost of $2,299,000. The loan is payable in equal monthly installments, including interest to 2004, and bears interest at the rate of 9% per annum. Interest cost on this loan, which was $196,000 in 1982 and $198,000 in 1981, has been included in program management expenses.

In 1979, the Institute entered into a contract for the construction of a facility near Homer City, Pennsylvania, to be used in conducting research involving coal-cleaning methods. Construction was financed from the proceeds of a $13,900,000 issue of tax-exempt Industrial Development Revenue Bonds issued by the Indiana County Industrial Development Authority (the Bonds), which are secured by a Crocker National Bank eight-year irrevocable letter of credit. The irrevocable letter of credit is subject to certain covenants. These include maintaining (a) relationships of long-term debt to annual revenue, annual principal and interest payments on long-term debt to annual revenues, and the sum of cash, marketable securities, and total member commitments to current liabilities and (b) member commitments in excess of a specified amount. The Bonds bear interest at $8\frac{3}{8}$% and are subject to mandatory redemption as follows.

1983	$ 1,665,000
1984	1,805,000
1985	1,960,000
1986	2,125,000
1987	2,305,000
1988	2,505,000
	$12,365,000

Total 1982 and 1981 interest costs for the Bonds were $1,089,000 and $1,164,000, respectively. Of the 1981 interest costs, $344,000 was capitalized and included in Property, Facilities, and Equipment. The remaining interest costs ($1,089,000 in 1982 and $820,000 in 1981) are included in contract research and development expenses. There is an interest and call premium reserve of 13% on the outstanding balance. At December 31, 1982, $2,555,000, representing the remaining proceeds, the reserve, and related interest earned, was on deposit with the Trustee in accordance with the Trust Indenture established at the time of the issuance of the Bonds.

NOTE 5—Commitments:

The Institute has entered into lease arrangements under operating leases for research, office, and storage facilities and for equipment. Rental expense under these leases was $1,329,000 in 1982 and $1,448,000 in 1981.

The terms of certain of these leases provide that the Institute is liable for property taxes, insurance, and maintenance expenses, and in certain cases, renewal options are included.

The Institute leases certain buildings under a long-term noncancelable lease, which is treated as the acquisition of an asset and the incurrence of a liability (Obligations under capital lease). The lease has an initial term of 30 years, expiring in 2008, and options to renew for two successive 10-year periods. The last 10-year option is subject to rental renegotiation. The capitalized cost of $3,807,000 is included in Buildings and land leases. (See Note 3.)

Future minimum lease commitments by year and in the aggregate, under the capital lease and noncancelable operating leases with initial terms of one year or more, at December 31, 1982, were as follows.

	Capital lease	Operating leases	Total
		(thousands of dollars)	
1983	$ 336	$1,451	$ 1,787
1984	336	1,442	1,778
1985	336	1,308	1,644
1986	336	1,182	1,518
1987	336	802	1,138
Thereafter	6,912	1,444	8,356
	8,592	$7,629	$16,221
Less amount representing interest	(4,972)		
Present value of the minimum capital lease commitment	$3,620		

Interest cost on the capital lease is included in program management expenses and was $295,000 in 1982 and $298,000 in 1981.

The present value of the minimum capital lease commitment of $3,620,000 is included in the accompanying statement of financial position as current and noncurrent obligations of $44,000 and $3,576,000, respectively.

NOTE 6—*Research funding:*

As the Institute identifies prospective research projects, the maximum amounts that may be expended on such projects are authorized and appropriations for them are approved annually. One responsibility of the Institute's staff is to negotiate research contracts with companies and organizations that result in a contractual commitment for a given year. Such commitments cannot exceed the cumulative appropriations.

The funding for the Base Program research projects is summarized as follows.

	1982	1981
	(thousands of dollars)	
Cumulative research expenditures made through the prior year-end on contracts since inception	$1,181,957	$ 963,828
Research expenditures, current year	257,840	218,129
Unexpended contract commitments	22,072	13,380
Amounts expended or committed under contracts since inception	1,461,869	1,195,337
Amounts authorized, not committed or appropriated	665,501	542,558
Total amounts authorized since inception	$2,127,370	$1,737,895

In addition to the unexpended contract commitments at December 31, 1982, in late 1982 the Institute entered into additional commitments with certain contractors for reimbursement of their 1983 research costs in the amount of $92,057,000. Generally, the Institute has the right to cancel research and development contract commitments on 30 days' notice.

NOTE 7—*Income tax status:*

The Institute has been determined to be exempt from federal income taxes as a scientific organization under Section 501(c)(3) of the Internal Revenue Code. Hence, only unrelated business income, as defined in the Code, is subject to federal income taxes. This year, as in prior years, the Institute has no taxable income.

NOTE 8—*Pension plans:*

The Institute has one pension plan for its employees, a defined contribution plan. The defined contribution plan conforms in all material respects to the provisions of the Employee Retirement Income Security Act of 1974. It is the Institute's policy to fund pension costs accrued. Pension expense was $2,618,000 for 1982, compared with $2,278,000 for 1981.

NOTE 9—Research and development expenses:

Research and development expenses for the Base Program by division are as follows.

	1982	1981
	(thousands of dollars)	
Advanced Power Systems	$ 56,139	$ 37,749
Coal Combustion Systems	48,452	37,728
Electrical Systems	35,341	31,291
Energy Analysis and Environment	33,129	30,191
Energy Management and Utilization	24,095	23,724
Nuclear Power	59,195	56,660
Other Divisions	1,489	786
	$257,840	$218,129

NOTE 10—Separately funded programs:

Supplemental information on revenues and expenses for separately funded programs is as follows for the years ended December 31 (thousands of dollars).

	1982						1981
	ISCCP	NSAC	RVP	SGP	Other	Total	Total
REVENUES							
Industry payments	$7,183	$5,923	$(5,330)	$1,855	$1,130	$10,761	$39,961
Interest income	616	608	918	1,264	6	3,412	4,327
Other income	—	1,574	97	—	—	1,671	5
Total revenues	7,799	8,105	(4,315)	3,119	1,136	15,844	44,293
EXPENSES							
Contract research and development	8,183	1,436	2,198	9,351	792	21,960	28,825
Program management and in-house research	441	7,996	230	1,354	—	10,021	9,649
Total expenses	8,624	9,432	2,428	10,705	792	31,981	38,474
EXCESS (DEFICIENCY) OF REVENUES OVER EXPENSES	(825)	(1,327)	(6,743)	(7,586)	344	(16,137)	5,819
FUND BALANCE, BEGINNING OF YEAR	3,713	3,998	6,943	8,086	—	22,740	16,921
FUND BALANCE, END OF YEAR	$2,888	$2,671	$ 200	$ 500	$ 344	$ 6,603	$22,740

Industry payments have been reduced by $5,165,000 and $2,507,000 for RVP and SGP, respectively, to reflect advance payments that are not expected to be used in the programs.

NOTE 11—Industry payments:

Industry payments for the years ended December 31 are as follows (thousands of dollars).

	1982		1981	
	Base Program	Separately Funded Programs	Base Program	Separately Funded Programs
U.S. electric utilities:				
Investor-owned corporations	$238,595	$ 5,557	$223,309	$31,786
Nonfederal government agencies	20,066	823	18,763	1,613
Federal government agencies	10,579	648	9,955	1,216
Cooperatives	6,580	251	6,362	592
Other sources	—	3,482	—	4,754
	$275,820	$10,761	$258,389	$39,961

REPORT OF INDEPENDENT ACCOUNTANTS

To the Board of Directors of Electric Power Research Institute, Inc.

In our opinion, the accompanying statement of financial position and the related statements of revenues and expenses and changes in fund balances and of changes in financial position present fairly the financial position of Electric Power Research Institute, Inc., both as to the Base Program and as to the Separately Funded Programs, at December 31, 1982 and 1981, and the results of its operations and the changes in its financial position for the years then ended, in conformity with generally accepted accounting principles consistently applied. Our examinations of these statements were made in accordance with generally accepted auditing standards and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances, including at December 31, 1982 and 1981, confirmation of cash and securities owned by correspondence with the depositaries.

Price Waterhouse

San Jose, California
March 2, 1983

ELECTRIC POWER RESEARCH INSTITUTE, INC.

Information current as of March 15, 1983.

ELECTED OFFICERS

William R. Gould, Chairman
A. J. Pfister, Vice Chairman
Chauncey Starr, Vice Chairman
Floyd L. Culler, President
Richard E. Balzhiser, Vice President
David Saxe, Vice President
Henry A. Darius, Secretary
Charles L. Menefee, Treasurer
Laura W. Huisman, Comptroller

SENIOR STAFF

Richard E. Balzhiser, Vice President
Research and Development Group

John J. Dougherty, Director
Electrical Systems Division

Fritz R. Kalhammer, Director
Energy Management and Utilization Division

René H. Malès, Director
Energy Analysis and Environment Division

Dwain F. Spencer, Director
Advanced Power Systems Division

John J. Taylor, Director
Nuclear Power Division

A. David Rossin, Director
Nuclear Safety Analysis Center

Kurt E. Yeager, Director
Coal Combustion Systems Division

Richard W. Zeren, Director
Planning and Evaluation Division

David Saxe, Vice President
Finance and Operations Group

Glenn N. Barber, Director
Administrative Operations Division

Henry A. Darius, Director
Corporate Affairs

Gail E. Parker, Director
Personnel Division

Charles L. Menefee, Director
Finance Division

Richard L. Rudman, Director
Information Services Group

Thomas M. Crawford, Director
Technical Information Division

Robert L. Loftness, Director
Washington Office

Ray Schuster, Director
Communications Division

Milton Klein, Senior Assistant to the President
Louis O. Elsaesser, Assistant to the President

RESEARCH ADVISORY COMMITTEE

Lawrence T. Papay, Chairman
Southern California Edison Company

Robert A. Bell
Consolidated Edison Company of New York, Inc.

Morris L. Brehmer
Virginia Electric and Power Company

Sol Burstein
Wisconsin Electric Power Company

Richard C. Clancy
Niagara Mohawk Power Corporation

John V. Cleary, Jr.
Green Mountain Power Corporation

Gerald F. Diddle
Associated Electric Cooperative, Inc.

Earl K. Dille
Union Electric Company

Paul Dragoumis
Potomac Electric Power Company

Johnny Lee Elliott
Duke Power Company

Peter H. Forster
The Dayton Power and Light Company

John W. Gore, Jr.
Baltimore Gas and Electric Company

William B. Harrison
Southern Company Services, Inc.

Sam A. Head, Jr.
Cullman Electric Cooperative

John T. Kauffman
Pennsylvania Power & Light Company

Marvin Klinger
Bonneville Power Administration

Byron Lee, Jr.
Commonwealth Edison Company

Stephen A. Mallard
Public Service Electric and Gas Research Corporation

George A. Maneatis
Pacific Gas and Electric Company

William M. Menger
Houston Lighting and Power Company

Claybourne Mitchell
The Detroit Edison Company

Norman E. Nichols
Los Angeles Department of Water & Power

Charles L. Steel
Arkansas Power & Light Company

Jack T. Stiles
Pacific Power and Light Company

Robert E. Uhrig
Florida Power & Light Company

L. James Walker, Jr.
Buckeye Power, Inc.

Leslie C. Weber
Northern States Power Company

J. Frederick Weinhold
Tennessee Valley Authority

ELECTRIC POWER RESEARCH INSTITUTE
Post Office Box 10412, Palo Alto, California 94303

EPRI